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CONTENTS

Original Papers:

Some Features of Tank Block Comparisons—Thompson and Vormelker 611
Enameling Defects Due to Cast Iron—Krynitsky 618
Gas Fired Enameling Furnaces without Muffles—Clark 623
Talc as the Principal Body Ingredient in Vitrified Ceramic Bodies—Kraner and McDowell 626
An X-Ray Study of Cyanite and Andalusite—Norton 636
Differentiation between Mullite and Sillimanite by Their X-Ray Diffraction Patterns—Navias and Davey 640
The Relation of Structure and Composition to Thermal Efficiency of Refractories When Used in Regenerators—Phelps 648
The Chemical and Physical Properties of Fire Clays from Various Producing Districts—Booze 655
Segregation in Bins—Garve 666
The Quantitative Determination of Iron Existing as Ferrosilicon in Artificial Corundum—Heindl 671

Ceramic Abstracts 265

Correction 295

The Bulletin:

Editorials 517
Papers and Discussions 527
Activities of the Society 549
Notes and News 556

Advertisers' Index 19

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ORIGINAL PAPERS

SOME FEATURES OF TANK BLOCK COMPARISONS[1]

By F. S. Thompson and H. I. Vormelker

ABSTRACT

The life of glass blocks can be increased by lower furnace temperature obtained by increasing the area of melting chamber, and by insulation of the walls. Analysis and physical tests of clays and of blocks made from them are compared with results of service test but data does not warrant conclusion.

Introduction

The glass house men present at the various meetings of the American Ceramic Society during the past year seem to be of the unanimous opinion that better tank blocks for glass furnaces is the most outstanding need of the industry. Some have gone so far as to point out that at the present rate of negative acceleration the life of our tanks will soon be zero.

The question of better refractories is an extremely important one, and the search should be pushed without stint; but we should not overlook the fact that a great many of the vituperations that are heaped upon the heads of the manufacturers of tank materials are not merited. All of these companies are as anxious to produce long service products as we are to receive them and we all know that several of the companies maintain expensive research departments for the purpose of developing the best product from the materials available.

[1] Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, Feb., 1925. (Glass Division.)

Factors Determining Service Life of Blocks

It has often been pointed out that the services of any particular tank should be given in tonnage produced per fire and not in total months of fire. It is the fair thing to do; yet, we have great difficulty in overcoming our tendency to compare one fire with another in a given tank by the number of months' duration of each. We have often heard tank men complaining that they are now receiving only eight months' service from a furnace that formerly gave twelve. As a usual thing no mention is made of the increased tonnage.

The life of a tank block is determined by various factors over some of which the tank block manufacturer has no control, such as, the temperature at which the tank is operated, the ratio of tank block surface to the tonnage produced, the design of the tank, and the composition of the glass. The factors which he does control are: the materials, the manner in which they are incorporated and the firing of the blocks. We shall take up each in turn.

Furnace Temperature

It is a well known fact that a clay substance softens and deforms at a much lower temperature than that required to fuse it completely. This softening point varies in different clays with variation in physical state and kind of minerals present. The temperature of beginning and the temperature range of this softening point have a definite bearing on the wearing ability of a tank block. For example, if a given tank block begins to soften at 1385°C and a furnace is operated above that point the corrosion will be much more rapid than it would be were the tank operated at a temperature of 1380°C. Furthermore, disregarding the softening point of clay, we all know that the speed of a chemical reaction is greatly accelerated by increase of temperature. At 100°C clay and glass in contact would remain clay and glass indefinitely, but at 1800°C there would be, in a few moments, an intersolution. After 1200°C the acceleration of solution is increased with increase in temperature. Since glass is melted in this rapidly accelerating period, it is a self-evident fact that the furnace should be operated at the lowest temperature consistent with production of the maximum quantity of good product.

Non-uniformity of Temperature in Tank

It is quite possible that the melting end of a tank could be operated at a temperature but little higher than the refining end if the entire capacity of the space were put to actual use. We know that the bottom portions of the glass move very slowly if at all. We know that glass actually passes through a tank from doghouse to production in one-third the theoretical time. The bottom portion is sluggish because it is viscous and it is viscous because it is cold.

One remedy for this condition has been suggested by Mr. Brownlee

of the Buckeye Clay Pot Company. His proposal for insulating the bath of glass tanks has been the basis for several discussions pro and con. Most of the criticisms that we have heard and read are in opposition. Most of them have not mentioned the most important feature that might be expected to result from tank insulation, that is, a lower operating temperature in the melting chamber. We base our assumption of a lower temperature on the increase of useful space made available.

Figure 1 shows a cross-section of a portion of insulated side wall and bottom. In the side wall the dotted line indicates the inside face of the block after several months of firing. This drawing is based on photographs of blocks removed from a tank melting soda-lime glass. If the difference in the degree of corrosion between the top and bottom is due to the difference in temperature it might be possible that with insulation, as shown, the wall would wear down more evenly. The wearing away at the flux line would be retarded by a lower operating temperature and the rate of solution on the lower part of the face would be increased by a higher temperature and more activity in the glass.

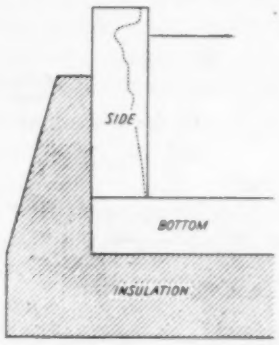


FIG. 1.

Another point that has been overlooked in the criticisms of this theory is the fact that no insulation is placed at or near the metal line. In fact this area should continue to be cooled by artificial means. With this arrangement we would have the region of greatest attack, operating as it does today with the exception of the advantage of a lower temperature. The lower portions of the side wall and the bottom would, of course, wear away more rapidly but there would be the advantage of the use of a greater volume of the tank capacity.

Ratio of Capacity to Production

The control of the temperature required in a continuous tank for melting good glass lies largely in the design of the furnace. It is, of course, possible to design a furnace to be used below its rated capacity, but this is not usual nor is it desirable. The increased fuel cost would not justify operating a tank below capacity. It is, however, desirable and economical to use a furnace at its rated capacity but not to overload it. Overloading requires use of increased temperatures with consequent shorter life of the tank. The argument is often advanced that it is economical to overload a tank and overcome the handicap of short life with increased production and lower fuel cost. This may be true in some cases but not a few experiences have proven that this often is an error.

A certain furnace was producing 22.9 tons each twenty-four hours on an

average of eight months. This tonnage was produced from a melting area of 296 square feet which is equivalent to 12.9 square feet to each ton. The furnace melting chamber was carried at 1410°C or higher for the entire run. This temperature was necessary to produce this tonnage of good glass. The coal consumption amounted to 22 tons per day.

At the end of the fire the melting chamber was enlarged to an area of 358.5 sq. ft., an increase of 62.5 sq. ft. With this change the average daily production has been exactly the same as formerly, 22.9 tons per day. But the temperature at the melting end is now 1350° to 1360°C (50° lower) and the average daily consumption of coal 19 tons or 3 tons less per day. These comparative figures, based on actual production and operation records, prove that there are times when a large furnace can be operated with less fuel than a smaller one.

TABLE I

	Melting area	Tons per day	Sq. ft. melted area per T. melted	Av. coal per day	Temp., degrees C
1st fire	296	22.9	12.9	22T	1410–1440
2nd fire	358.5	22.9	15.6	19T	1360–1380

It is quite apparent that the furnace blocks will give a far better account of themselves at the lower temperature than at the higher.

Glass Composition

It is commonly held that the different glasses have different corrosive effects on tank blocks; that is, a given tank might last for fifteen months on one variety of glass and eight months on another. Yet most glass men buy and receive, and most clay works sell and ship, the same block for all glasses. It is our belief that for each glass there is a refractory most suitable and that an effort should be made to determine the character of a refractory most suitable to each type of glass.

Investigation of Clays and Blocks

In January of 1924 we received sample blocks and a small quantity of the prepared clay with which the blocks were built. We subjected the clay to various physical and chemical tests. The results indicate the wide degree of variation in the raw materials used for tank block construction. Not only were the physical characteristics widely variable but the chemical analyses also showed the products to be indeed markedly distinctive.

Chemical Composition

The following table gives the silica, alumina and iron oxide content of eight standard blocks that are on the market today, and the approximate analysis of the clays, unfired, of which each block was made.

TABLE II

	Tank block			Unfired clay		
	SiO_2	Al_2O_3	Fe_2O_3	SiO_2	Al_2O_3	Chem. water
1	77.8	21.0	0.7	72.7	20.0	6.7
2	77.4	17.8	2.3	73.4	17.1	5.0
3	76.3	22.0	1.3	71.9	21.0	5.3
4	68.7	27.6	2.6	62.8	25.3	8.6
5	67.3	29.6	2.1	61.1	26.9	8.9
6	63.8	28.2	3.9	....	....	...
7	73.4	22.8	1.8	....	....	...
8	56.5	39.0	2.1	50.1	34.6	11.2

Physical Tests of Clays

Drying shrinkage of the raw clays also showed a range of differences. To obtain these figures ten bars of 1-inch square cross-section and 6 inches long were made up of equal parts of standard sand and sample clay. Marks were laid off near the ends of the bars with a razor blade and the intervening distance measured. The sample bars were then dried at room temperature and at 120°C and measured again. The following figures show the average shrinkage of each of the clays from which the eight blocks in question are made.

TABLE III

Clay	Per cent linear shrinkage	Rupture modulus, lbs. per sq. in.	Clay	Per cent linear shrinkage	Rupture modulus, lbs. per sq. in.
1	1.81	104	5	2.57	140
2	3.48	427	6	2.85	178
3	3.70	258	7	2.45	135
4	2.96	156	8	2.61	187

The modulus of rupture of these same clays was obtained according to the procedure of the American Ceramic Society Standard Test. The bars were 7 inches long and approximately 1 inch square in cross-section. They were composed of equal parts of standard and sample clay.

From this wide field of selection the block manufacturer has been choosing his raw materials. Usually his choice rests upon expediency and custom; that is, he chooses a clay that always has given a certain amount of satisfaction and is easy to prepare, mold, dry and fire. Since a great many clays of divers compositions fill all these requirements, it follows that our tank blocks are not likely to be of uniform composition.

The question of the effect of the composition of the tank block upon its quality of service naturally arises. It is reasonable to assume that compounds or solid mixtures of different composition will react differently in contact with a definite reagent; that is, we might readily expect that a block containing 77% silica will show a different resistance to corrosion by glass than one containing 50% silica. We might also look for different performances from two blocks containing, respectively, 7 parts of Fe_2O_3 per thousand and 40 parts of Fe_2O_3 per thousand.

Therefore, we might be justified in assuming that these different blocks of varying composition would show different degrees of corrosion in contact with the same glass. If the degree of corrosion is different one must be the greatest and one the least or, in other words, one must be the poorest and one the best in contact with that particular glass.

It would seem, therefore, that a good starting point in the search for better blocks would be the selection, by each manufacturer, of the type of block best suited for his glass from among those already on the market.

We are well aware that it is an unwritten law of the glass house that the only real test of a tank block is to build it into the furnace and find out how long it will last.

This may be the only trustworthy test, but we should not be deterred from seeking other methods of determining the wearing qualities of a block in a few hours or days instead of a few months or years. We are now seeking such a method. We realize that our efforts result in but a very small fraction of the information necessary for a definite conclusion. Satisfactory results will be attained only from a cumulation of data.

Assuming that the greater part of the destruction of the tank block is due to physical abrasion and chemical action between the clay and the glass we set about to obtain some method of comparing tank block solubilities in glass. There are other properties that affect the life service of a block but these two factors seem to be the most important. Inasmuch as porosity has a relation to each of these two properties the figures showing the percentage pore space were determined.

The investigations by R. M. Howe, S. M. Phelps and R. F. Ferguson dealt with the action of slag on various refractory materials. This can be considered a subject closely akin to the one we are discussing.

Solubility Test A quantity of chips from the tank block were pulverized in a ball mill and screened. That which passed through the 180-mesh and stayed on the 200-mesh sieve was mixed with a soda-lime glass batch in the proportion of three to one (75% clay—25% batch). This mixture was pressed dry into plaster molds to form cones the size and shape of Orton Standard cones. The mold and contents were placed in an electric muffle furnace and heated to 650° to frit them into solid form of sufficient strength to permit handling.

Two of these cones were then placed on a pat with a series of Standard Orton cones. The pat was placed in a surface combustion furnace and the temperature raised at the rate of 10° per minute. When the test cones were bent to the pat the gas was turned off and the result noted in terms of Orton cones.

This test is based on the assumption that the cone composed of the mixture the most readily intersoluble would fail first. The results are shown in Table IV.

TABLE IV

	Solubility		Abrasion per cent loss	Per cent porosity	Apparent density
	Failed at cone	Approx. temp., °C			
1	7—	1265	6.2	23.0	2.25
2	6	1250	9.9	23.6	2.24
3	10—	1325	8.4	23.9	2.26
4	12—	1325	60.1	28.1	2.18
5	6	1255	4.6	23.7	2.23
6	8	1290	16.3	26.5	2.19
7	8	1295	11.6	30.1	2.15
8	14—	1400	40.1	23.0	2.28

Abrasion Test

A portion of the sample block was broken up into pieces as near cubical as possible, approximately $1^1/_2$ inches. Selected pieces were then placed in a ball mill and given a preliminary grinding. This operation ground off the sharp corners and reduced the pieces to a more or less rounded shape. From among these pieces were chosen those of most uniform size and shape.

One hundred and fifty grams of the chosen pieces were placed with 1000 grams of flint pebbles in an 8-inch ball mill and rotated for a period of two hours at a rate of 80 revolutions per minute. The charge was then removed and placed on a 10-mesh screen and subjected to the action of a Tyler Ro-Tap until nothing remained on the screen but the flint pebbles and the remaining portion of the sample pieces. The latter were removed and weighed and the loss noted. The percentage of this loss gave some idea of the resistibility of the block to abrasive action.

The results of this test on the eight blocks are shown in Table IV.

Two samples of English tank block showed porosities of 17.2% and 17.8%, respectively, although they were of porous appearance. On the other hand we examined a clay block and a sillimanite piece that were made and sold as "dense" material. They showed porosities of 30.25% and 39.4%, respectively. Other instances that have come within our observation have indicated that efforts to make a dense block have generally resulted in a higher porosity and, of course, less density. However, if the pores be sufficiently minute the block might be considered as equivalent to one of low porosity even though it measured 40%. The surface tension of the glass would probably be sufficient to prevent penetration.

Such figures as the foregoing obviously are not a complete basis for final conclusions. We have desired merely to point out the marked differences in the principal characteristics of commercial blocks. Each one of the tests described shows that the commercial blocks now on the market vary in properties between wide limits.

GLASS TECHNOLOGY DEPARTMENT
NELA PARK, CLEVELAND, OHIO

ENAMELING DEFECTS DUE TO CAST IRON

By A. I. Krynitsky[1]

ABSTRACT

A discussion of Malinovszky's paper on enameling defects due to cast iron. Problems are suggested for further investigation on the subject.

A. Malinovszky has published a very interesting paper "Enameling Defects Due to Cast Iron."[2]

In the beginning of his paper Malinovszky states that "blisters, if caused by the iron, seem to be governed by the condition and size of the graphitic carbon. The presence of slag or dirt in the castings or at the surface of the casting also can cause chipping, lifting, black specks and blisters" and in the summary he adds that "it seems that as soon as the combined carbon is high and if temper carbon is present the blistering of the enamel is certain."

These important conclusions which are the essence of the paper appear to the writer as not having been sufficiently substantiated. For example, in describing Fig. 7 the author writes: "This sample was taken from a perfect enameled tub. The sample has abundant graphitic crystals, most of which are arranged with flat face parallel to the enameled side. Free cementite occurs sparingly and is more abundant toward the enameled side."

It is to be regretted that chemical analysis and magnification are not reported for each micrograph. From the table of chemical analysis given for three tubs before and after enameling it follows, however, that there is a substantial loss in combined carbon after enameling and that in almost all cases, except that of the $5^1/_2$-ft. flat rim tub before enameling, we have to deal with the hypoeutectoid irons and therefore ought to expect the presence of free ferrite rather than free cementite. It is assumed that the magnification in the micrographs was about 100 ×.

On examining Fig. 7 and bearing in mind the foregoing remarks one would interpret the micrograph as representing a mass of pearlite, a small amount of ferrite and comparatively large flakes of graphite.

There is another sample of iron reported by Malinovszky as giving no trouble from blistering and being probably a very good iron for enameling; it is represented by Fig. 3. Examining the structure in this figure we notice again the presence of a large amount of pearlite, comparatively small amount of free ferrite (or free cementite?) and small graphite flakes.

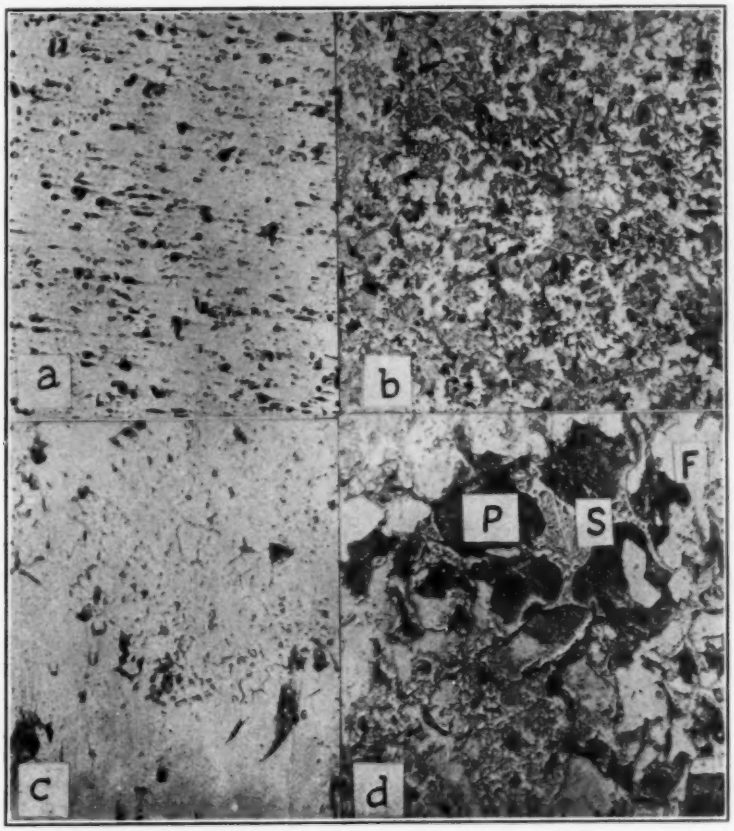
It is not believed that these two examples could lead us to such a conclusion as that which the author offers in his summary; *i. e.* "It is clearly shown that a low combined carbon and an evenly distributed graphitic carbon in very minute state will show no signs of blistering."

Referring now to his Fig. 6 we may note that, although it is very probable

[1] Recd. July, 1925.

[2] *Jour. Amer. Ceram. Soc.*, **8** [1], 72–8 (1925).

that temper carbon may cause blistering, this figure appears not clear enough as to warrant such conclusion.



a—Polished. × 100 *c*—Polished. × 500.
b—Etched in 5% picric acid. × 100. *d*—Etched in 5% picric acid. × 500.
F—White, structureless constituent—ferrite.
P—Dark constituent—pearlite.
S—White, mottled (dotted) areas—binary phosphide eutectic, so-called "Steadite." It contains according to Stead about 10% P and 90% Fe.

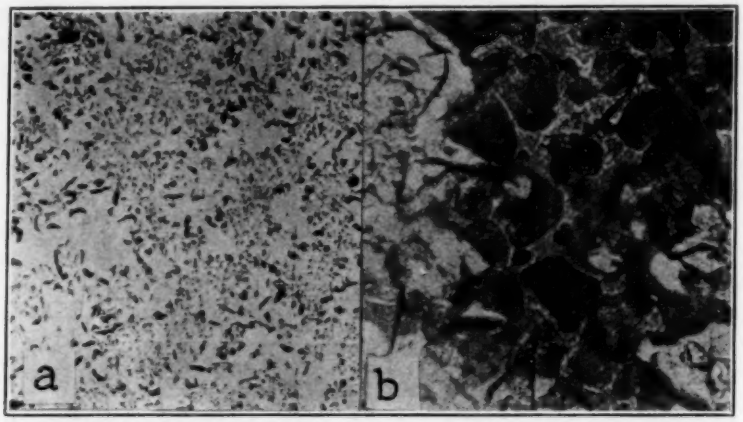
FIG. 1.—Heat No. 1.

Effect of Iron Composition and Crystallization

While it should be understood in the discussion below that there are not enough data, as yet, on hand to warrant any definite conclusion, still it was thought that the following observations will be of interest in connection with the foregoing discussion.

A number of samples in the form of plates 3″ x 6″ x $^3/_{16}$″ cast in green sand molds and prepared for enameling test were ground down about 0.01″

on the drag side and examined microscopically. Micrographs given below show the structure of the drag side of specimens before enameling. They represent 3 different heats of the same iron and they agree fairly well with the microscopic observations made on the cross-sections of the similar specimens.



a—Polished. × 100. *b*—Etched in 5% picric acid. × 500.
FIG. 2.—Heat No. 2.

The chemical analysis and proximate structural composition are given in the table below:

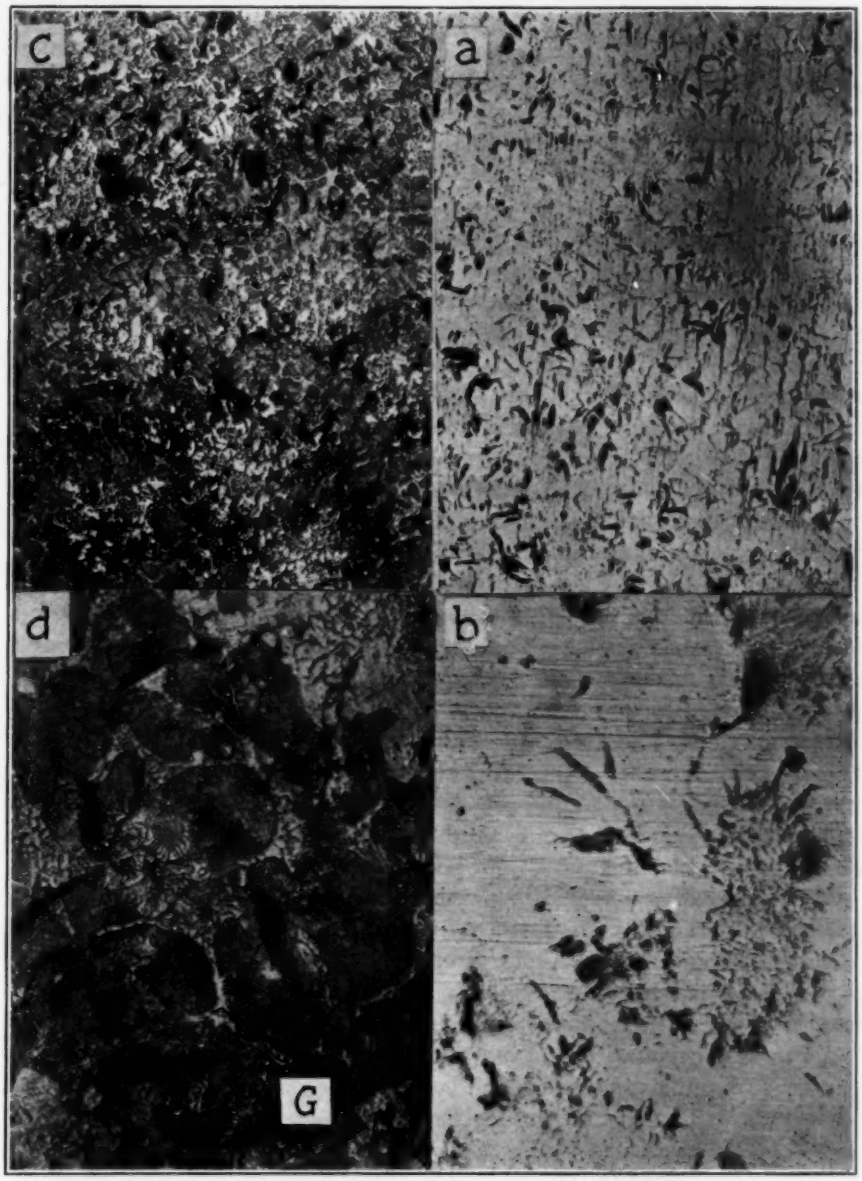
CHEMICAL ANALYSIS BEFORE ENAMELING

	Heat No. 1 %	Heat No. 2 %	Heat No. 3 %
Total carbon	3.40	3.25	3.22
Mn	0.69	0.57	0.44
P	.814	.845	.840
S	.048	.058	.086
Si	2.82	2.77	2.69
Graphitic carbon	3.18	2.84	2.74
Combined carbon	0.22	0.41	0.48

PROXIMATE STRUCTURAL COMPOSITION BEFORE ENAMELING

	Heat No. 1 %	Heat No. 2 %	Heat No. %
Pearlite	27.9	49.6	57.7
Free ferrite	60.7	39.0	31.0
Steadite	8.1	8.45	8.4
Graphite	3.2	2.8	2.7
Mn S	0.1	0.15	0.2

From the chemical analysis it may be seen that the total carbon—and graphite carbon—content is gradually decreasing from the first to the third heat, while the combined carbon content gradually increases. A gradual increase in the sulphur content is to be noticed.



a—Polished. × 100.
b—Polished. × 500.
c—Etched in 5% picric acid. × 100.
d—Etched in 5% picric acid. × 500.
G—Graphite.
Steadite is seen in *d*.

FIG. 3.—Heat No. 3.

Figure 1. *a*, *b*, *c* and *d* show the structure corresponding to heat No. 1 The presence of a large amount of ferrite and some steadite are to be noted. Graphite is shown as round patches composed of very small particles and also in smaller quantity as flakes of larger size.

Specimens of heat No. 2 are represented by Fig. 2, *a* and *b*. An increase in the quantity of pearlite and in the size of graphite particles is to be noticed.

The structure of plates from heat No. 3 is shown in Fig. 3, *a*, *b*, *c* and *d*. A large amount of pearlite and comparatively large sized flakes are found present.

According to the results of enameling test made by the Enameled Metals Section, Ceramic Division, Bureau of Standards (unpublished), there were a number of blisters observed on the enameled[1] iron from heat No. 1, while hardly any were noticed in those from heats Nos. 2 and 3. Thus, if one would base his conclusions on these observations he could state that the quantity of graphite and size of the graphite flakes are of greater importance than the amount of combined carbon in the irons for enameling purposes.

Although there are indications and certain theoretical considerations that a large amount of combined carbon is undesirable in irons used for enameling, this is not evident from the paper discussed above and there are not yet available enough data to warrant such a conclusion. Blistering appears to be a complex phenomenon and there are evidently several factors which might exercise great influence on it. For instance, when working on the theory that carbon is the principal factor which causes blistering one may suppose: (*a*) That the presence of large graphite particles is more desirable than that of the very small particles when the iron to be enameled is treated only by sand blasting and when no preliminary annealing is being employed, for the large particles may be affected more easily by sand blasting and do not burn as readily as the smaller ones do.

(*b*) That casting temperatures and rate of cooling which control the amount of combined carbon, the size and shape of graphite particles, the preliminary heat treatment, the temperatures employed, the time of exposure at the high temperature, the extent of the decarburization of the surface to be enameled, etc., must be always borne in mind.

All these considerations suggest problems for the systematic investigations. It would also be desirable to obtain data on enameling tests made on pure as well as on commercial irons and also on steels, white, mottled and malleable cast irons.

The data obtained for the discussion of this paper have been gathered in connection with the investigation of cast iron for the enameling purposes carried on in the Bureau of Standards in coöperation with the Enamel Division of the AMERICAN CERAMIC SOCIETY.

[1] Wet coat. Ground 900°C—5½ min.; cover 840°C—6 min.

GAS-FIRED ENAMELING FURNACES WITHOUT MUFFLES[1]

By H. H. Clark

ABSTRACT

First attempts to design enameling furnaces reveal unsuccessful results to increase efficiencies. The early attempts to eliminate the undesirable feature of coal-fired furnaces resulted in building furnaces having high thermal heads, uneven heat distribution and which were costly to maintain.

Eventually the intermittent type of enameling furnace was developed. The only possible disadvantage of this type is that speed forks cannot be used.

An example of the installation of a semi-muffle gas-fired enameling furnace in the plant of the Cribben and Sexton Company, Chicago, is cited. Its principal feature is constant atmospheric conditions accomplished by high pressure gas burners. The design, details, performance data and operating costs are given. A résumé stating the many advantages of gas are appended.

Porcelain enameling furnaces for either the sheet steel or cast iron wet process, up to a few years ago, were practically all of the full-muffle type. Most of them used coal for fuel; the coal was fired into the rear end of the furnace. To increase the efficiency higher grade refractories were used in the muffle. However, these refractories did not offset the disadvantages of this type of furnace. To eliminate falling arch tile and uneven heat distribution, a great many other types of furnaces were designed.

Most all of the attempts to build an enameling furnace that would eliminate the undesirable features of the old coal-fired furnaces adhered closely to the original principles of enameling furnace design whether the fuel used was coal or oil. The products of combustion were kept out of the working chamber by a wall of refractory material. This type of furnace requires a high thermal head to drive the heat through the refractory walls. This, of course, results in high maintenance costs as the difference in temperature between the working chamber and the combustion chamber is often as high as 400°F.

Another disadvantage of the old type of furnace was the uneven distribution of heat. When firing a furnace from either the front or rear it is impossible to keep from getting a difference in temperature in the furnace.

To eliminate numerous shut-downs caused by muffle tile breaking or burning out, and to eliminate the unevenness of heat, the intermittent type was designed. A number of these furnaces have been in operation using gas fuel service for the past few years. This intermittent type of furnace has proved to be very satisfactory, largely because it has reduced maintenance costs; it has made even heat distribution possible, and it is possible to burn ware in the presence of a falling temperature. The only possible disadvantage of this type of oven, if any, is that the various speed forks cannot be used.

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[1] Presented at the Annual Meeting of the American Ceramic Society, Columbus, Ohio, Feb., 1925.

One of these intermittent type furnaces fired with gas has been in operation at the plant of the Cribben and Sexton Company at Chicago for two years. (This concern makes high grade stoves and ranges.) This firm wished to install speed forks on their furnaces. To meet the necessary requirements of speed forks it was decided to build a gas-fired continuous semi-muffle type furnace. The engineers of the Surface Combustion Company together with the coöperation of The Peoples Gas Light & Coke Company of Chicago designed a furnace of this type and installed it in this plant. The principal features of the design are the means adopted to secure constant atmospheric conditions. This was accomplished by using high pressure surface combustion gas burners. These burners give absolute control of the products of combustion. Gas fuel is ideal for this furnace on account of the short flame. This characteristic gives complete combustion under the hearth and only the hot gases ever get into the working chamber.

To get an even distribution of heat, five small burners were placed on each side of the furnace. This gave the same temperature at the door as at the back of the furnace. By having a number of small burners with individual control on each burner and a main control on the gas line, absolute control of heat distribution in the furnace is attained.

The maintenance costs are low on this furnace on account of the elimination of the muffle and the construction of the semi-muffle in its stead. The furnace has a hearth surface of 10 feet deep, 4 feet wide, and the inside height is 2 feet. The hearth and side wall are of carborundum. The outside walls are of 9 inches of fire brick and $13^1/_2$ inches of insulation, all of which is enclosed in a sheet steel case.

This furnace has been in operation for four months and very good results have been secured. This plant is equipped with hand operated forks, two men to a furnace. At the present time a speed fork is being installed and will, of course, show greater production.

Over the period of time this new furnace has been in operation the gas consumption has averaged 1222 cu. ft. per hour of operation which is at the rate of 72 cents per thousand cu. ft. or 88 cents per hour. The work produced has been of sheet steel and the cast iron wet process. The sheet steel varied in gage from number 18 to number 20. The pieces were of sizes varying from $3^1/_2$ sq. ft. to 3 sq. ft. in area; 8 pieces to 100 pieces per load.

The average hourly production has been 531 sq. ft. with hand loading and two men to a furnace. For a few days four men were employed to feed this furnace and the production was increased to 650 sq. ft. per hour, but it was found that the men were in each other's way. But the more pleasing result of this trial run was that the temperatures remained constant no matter how fast the furnace was fed. By operating one gas valve

the operators have absolute control over the temperature of the furnace. This can be made automatic, of course, if desired.

On the basis of four months of operation we find that the cost per one-hundred square feet of ware enameled with one coat is 20 cents. This cost is derived as follows:

1222 cu. ft. gas at 72 c. per thousand cubic feet	$0.88
Gas compression expense including power, water, labor	.03
Maintenance	.02
Interest, depreciation, taxes on furnaces and equipment	.14
	$1.07
Average hourly production (sq. ft. of ware enameled)	531

Cost per 100 sq. ft. of ware enameled = $1.07 ÷ 531 = $0.20.

The excellent condition of the furnace after the first four months of continuous operation indicates that its maintenance cost over a long period of time will be practically nothing.

At the present time material is being secured for the purpose of building a similar furnace. This new furnace will be 5 feet wide, 12 feet deep, and 2 feet high (hearth dimensions). This will give a hearth area 50% in excess of the oven formerly mentioned. Tests indicate that gas consumption will be about 10% greater. The reason for this is that the hot gases have a longer travel and the flue gases will consequentially be lower in temperature.

The advantages of the semi-muffle type gas-fired porcelain enameling furnaces are: (1) low maintenance costs, (2) even distribution of heat, (3) absolute control of furnace temperatures, (4) absolute control of furnace atmospheric conditions, (5) superior finished product, (6) low production costs.

TALC AS THE PRINCIPAL BODY INGREDIENT IN VITRIFIED CERAMIC BODIES[1]

By Hobart M. Kraner[2] and Samuel J. McDowell[3]

ABSTRACT

This paper is an attempt to explain the firing behavior of pure talc as well as talc-clay, talc-lime, talc-clay lime, and some other high magnesia mixtures. Phase rule equilibrium diagrams are used. The study applies only to those mixtures where talc is present in amounts greater than 50% of the total composition.

Introduction

Purely theoretical reasoning or the application of theories and data not ordinarily considered ceramic lead often to the solution of many ceramic problems. The firing behavior of steatite (talc), and other high magnesia bodies bonded with clay warrants a study of this sort, and the phase rule diagrams are available for it.

The vitrified products made from such compositions are said to have very desirable characteristics. It is claimed that they possess the highest insulating value of any ceramic material produced at similar temperatures. A low coefficient of expansion, high thermal conductivity, high thermal diffusivity, as well as high dielectric strength is claimed for them.

Pure Talc and Its Melting Behavior

The difficulty in the manufacture of a ceramic product of this type seems to be in controlling its vitrification. The temperature range giving proper vitrification is very narrow and the ware is likely to be either porous from underfiring or bloated and melted from overfiring. On this account it is very difficult to hold the ware to specified dimensions, porosity, or shape. It is said that one manufacturer regularly found it necessary to scrap 60% of his ware. The result is that many steatite products are either fired to a low temperature and left porous, or their manufacture is discontinued.[4]

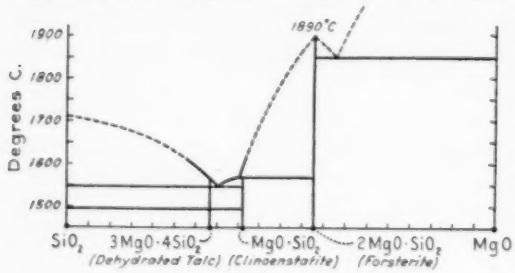

FIG. 1.

[1] Recd. July 1, 1925.

[2,3] A.-C. Spark Plug Co., Flint, Mich.

[4] Some of the ceramic industry are interested in compositions which are largely talc or other high magnesia minerals bonded with clay. The magnesia mineral in such bodies is the principal ingredient. Deductions made from a body study of this sort cannot therefore be applied to the behavior of other compositions where talc or other high-magnesia mineral is present only in small amount.

Theoretically the molecular composition of pure talc is $3MgO.4SiO_2.H_2O$. Its chemical composition is MgO 31.9, SiO_2 63.3, H_2O 4.8.

It is not likely that many such talcs occur in nature. Dana's system of mineralogy gives the following analyses for selected samples of the mineral:

	SiO_2	FeO	MgO	H_2O	Al_2O_3	NiO	CaO
1	62.12	1.58	31.15	4.73	....	0.24	....
2	61.16	1.40	31.17	5.31	0.46	.39	....
3	60.85	0.09	32.08	4.95	1.71	....	trace
4	62.15	.39	33.04	3.21	1.01	....	0.07
5	61.51	.12	30.93	2.84	0.83	....	3.70
6	62.37	.65	32.02	4.81	.32	....	....
7	60.31	2.11	29.94	5.87	1.24	0.30	....
8	61.69	2.33	30.62	4.94	....	.29	....
9	62.03	1.57	30.62	5.04	0.03	.32	....
10	57.10	1.07	30.11	6.07	5.50	....	....
11	61.51	1.38	30.27	4.88	1.08	1.06	....
12	63.29	4.68	27.13	4.40	1.40	....	trace
13	64.44	1.39	33.19	0.34	0.48	0.23	....
14	57.72	0.64	33.74	6.01	2.52	....	....
15	62.27	.85	30.95	4.91	1.10	....	....

Diller, Fairchild and Larsen[1] give the following compositions:

	SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	H_2O	
1	61.37	1.96	..	1.47	30.23	none	....	5.36	German
2	61.00	2.12	..	1.74	29.83	none	....	5.56	Indian
3	61.52	0.84	..	1.27	31.38	none	....	5.42	Italian
4	61.94	1.52	..	0.97	31.55	none	....	5.19	French
5	61.35	4.42	..	1.68	26.03	0.82	0.62	5.10	N. Carolina
6	58.68	3.75	..	5.52	26.80	none	....	5.33	Maryland
7	61.00	0.59	..	....	30.84	....	....	5.40	California

If we locate the composition of chemically pure dehydrated talc on the MgO-SiO_2[2] binary diagram as is shown in Fig. 1, it is evident that it is composed largely of the clinoenstatite-silica eutectic composition. Actual calculation shows it to be 95% eutectic composition.

The eutectic melts at 1543°C and eutectic melting is sharp. It is therefore evident that pure talc has practically no firing range and would become fluid almost immediately as soon as that temperature is reached. The excess constituent in this case is 5% silica, but this low percentage of excess solid material would not affect the fluidity of the melt.

Clay and Talc Mixtures

The effect of the addition of clay to talc can be studied on the MgO-Al_2O_3-SiO_2 ternary diagram[3] shown in Fig. 2.

[1] *Econ. Geol.*, **15**, 574–609 (1920).

[2] N. L. Bowen and Olaf Andersen, "The Binary System MgO–SiO_2," *Amer. Jour. Sci.*, **37**, 478 (1914).

[3] Rankin and Merwin, "The Ternary System MgO–Al_2O_3–SiO_2." *Amer. Jour. Sci.*, **45**, April (1918).

The broken line connecting the compositions $3MgO.4SiO_2$ (dehydrated talc) and $Al_2O_3.2SiO_2$ (dehydrated clay) shows that portion of the field along which mixtures of talc and clay fall. It will be noted that the lowest melting eutectic in the system is nearly on this line, having the composition MgO 20.3, Al_2O_3 18.3, SiO_2 61.4.

This could be compounded from the following:

Raw talc ($3MgO.4SiO_2.H_2O$)	58.1
Raw clay ($Al_2O_3.2H_2O.2H_2O$)	41.5
Alumina (Al_2O_3)	0.4

When ware composed of talc and clay is to be formed by the wet process, the composition necessarily approaches the above eutectic composition very closely. Just how near the eutectic composition it will be, of course, depends upon the exact amount of clay used. Inasmuch as eutectic melting is sharp, there would be very little, if any, sintering preceding the melting at the eutectic temperature. Complete melting occurs at the eutectic temperature. In such a case a few degrees in temperature means the difference between a porous piece of ware and a melted one. This has been proven in practice. Pieces in the same sagger have shown the effect of this small temperature variation. Bonding talc with clay is obviously not to be recommended where the amount of clay is 40% or 50%.

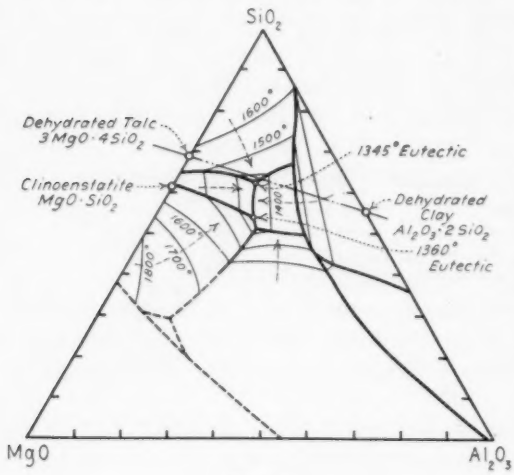

FIG. 2.

Pure Talc in Other Mixtures

Compositions along the broken line (Fig. 2) between the 1345° eutectic and anhydrous talc would be somewhat less difficult to fire, but the theoretical range would still be only that between the melting temperature of the ternary eutectic and the temperature represented by the elevation of these compositions on the surface of the solid diagrams whose slopes are indicated by isotherms and arrows pointing toward the lower temperatures.

Figure 3 shows the position of composition X on the MgO-Al_2O_3-SiO_2 ternary diagram. In this composition silica (SiO_2) is the crystalline phase in excess of the liquid immediately before melting is complete. This should

improve the firing range of the body but the flatness of the field as indicated by the large distance between the isotherms means that a relatively large amount of silica would go into solution in this glass with only small increases of temperature above the eutectic temperature. In some porcelain bodies, the undesirability of the physical properties of the silica minerals would also be a consideration.

Effect of Increase in MgO

From their locations on the ternary diagram, the bodies in the regions thus far considered have either clinoenstatite ($MgO.SiO_2$), or silica (SiO_2), as the primary crystal phase—the last to go into solution upon heating the mixture.

If clinoenstatite is the constituent which contributes valuable properties to these bodies, it is of course necessary to maintain compositions in which it is the excess constituent. If MgO is the most important consideration, other more practical bodies higher in MgO might be considered. Fused MgO and periclase have very high dielectric strengths.[1] It would seem therefore that higher MgO bodies should be considered.

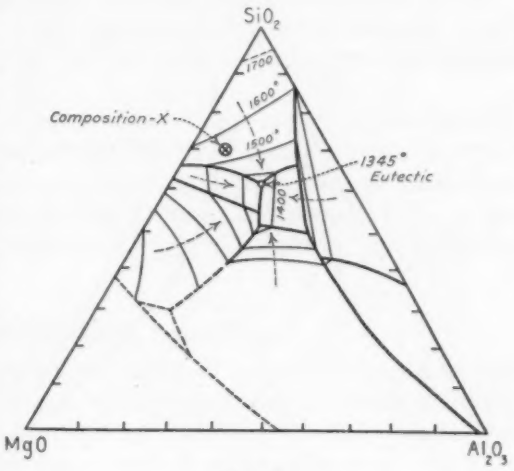

FIG. 3.

A Japanese patent[2] claims that the $MgCO_3$ content of the following mixture is very important in its successful firing.

Talc (raw)	25	Feldspar	10
Talc (calcined)	30	$MgCO_3$	5
Clay	30		

On a basis of phase rule study the real value of only 5% $MgCO_3$ might be questioned. Sufficient MgO addition would, however, place a talc-clay mixture in the forsterite field. It is to be noted that the forsterite field is large, and that the temperature at which the mineral itself melts

[1] P. H. Brace, "The Electrical Conductivity of Magnesia and Porcelain at High Temperatures." *Trans. Elec. Chem. Soc.*, p. 205 (1918).

[2] *Ceram. Abs.*, **2**, 199 (1923).

is relatively high (1890°C) as compared to the melting temperature of the low ternary eutectic (1345°C).

Figure 4 shows composition *Q* lying within the forsterite field of the system forsterite ($2MgO.SiO_2$)–cordierite ($2MgO.2Al_2O_3.5SiO_2$)–spinel ($MgO.Al_2O_3$), but since the 1360° eutectic is questionably a eutectic,[1] and since in practice the composition would probably not be made up from the minerals mentioned, the 1345° eutectic would be the liquid phase to appear first.

In any system where a compostion is compounded from substances other than the mineral components which would be in equilibrium with each other at an elevated temperature, the lowest eutectic in the system will be the first to form as the temperature is raised.

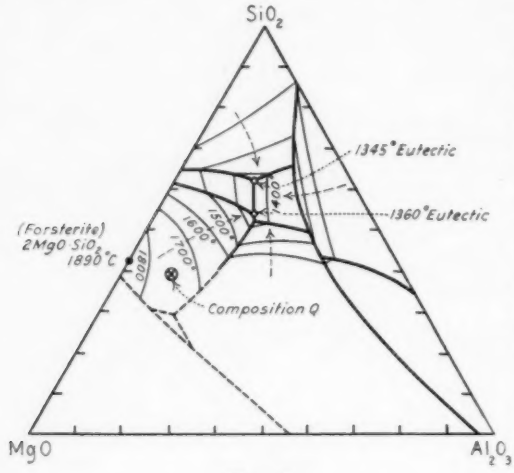

FIG. 4.

In the case of composition *Q* when compounded from $MgCO_3$ (or MgO), talc, and clay, the 1345° eutectic would form first. The stable phases would crystallize from this melt even as the temperature is increased and so long as any of the liquid exists whose composition is located in the distant field.

The forsterite field would seem to have some possibilities so far as a longer firing range is concerned although the compositions on the slope between the clinoenstatite-silica valley and forsterite would feel the effect of the fluid 1345° eutectic as soon as it is formed.

There are practical objections arising to the compounding of mixtures in the forsterite field directly from talc, clay and $MgCO_3$ or MgO. The firing loss in $MgCO_3$ is considerable, and a high shrinkage takes place in the piece when this is used. MgO, even electrically fused, as well as $MgCO_3$ hydrolyzes sufficiently to affect the plasticity of the clay used.

Calcination of the MgO-talc mixture to obtain forsterite ($2MgO.SiO_2$) suggests itself as a means of chemically combining the MgO to prevent its hydrolysis. It must be remembered, however, that this cannot be done completely during calcination unless there is considerable liquid phase present from which the stable phases can crystallize. If the temperature is maintained near or only slightly above that at which this liquid phase

[1] Rankin and Merwin, *loc. cit.*

remains so, the amount of liquid will decrease to such an extent as to make it mechanically impossible for crystallization to proceed to equilibrium. A temperature considerably higher than the melting point of this first liquid phase should be reached to make combination of the MgO likely. Electric furnace melting suggests itself as the most suitable method.

If forsterite as such is bonded with clay, the 1345° eutectic forms first, as before, but the shrinkage is minimized and the range of firing is wider than when talc is used. However, a body of forsterite 70, raw clay 30 would contain about 68% of the 1345° eutectic. This large amount gives little range between the sintering temperature (eutectic temperature) and softening.

Increase of the MgO content beyond the forsterite composition of MgO 57.1, SiO_2 42.9, in an electric furnace product would seem to be the most hopeful possibility inasmuch as the addition of clay to this material would bring the resulting mixture farther from the eutectic area and should lengthen the firing range.

The limiting composition in the addition of MgO in such a fused product is the forsterite-periclase eutectic (see Fig. 1). Mixtures richer in MgO, even after complete fusion, would leave MgO as the excess constituent and therefore free to hydrolyze if given a chance in a ceramic body in the plastic condition. The effect of the hydrolysis would be noted in the workability of the mixture.

Bodies Containing Impurities

Definite information regarding the effect of a few ceramic materials either as impurities or as additions to the batch upon the firing behavior of a pure talc can be obtained from temperature-composition equilibrium diagrams. Unfortunately, the complexity of many ceramic compositions precludes the possibility of diagraming their components and studying their probable firing behavior. We do know, however, that small quantities of many fluxes are conducive to a long firing range. With a large number of fluxes present, the eutectics are complex and their melting temperatures are lower than if the same mixtures were more simple. Inasmuch as the eutectic temperature determines the temperature of sintering, and the percentage of eutectic determines the range between sintering and complete melting, it is possible to exercise a certain amount of control over the firing range.

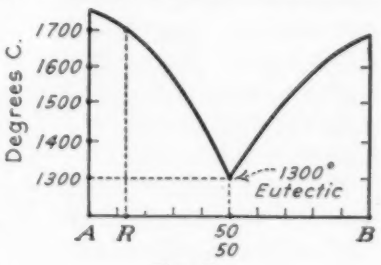

FIG. 5.

Consider Fig. 5. A binary eutectic, 50% A, 50% B, melts at 1300°C.

Composition *R* melts completely at 1700°C. Eutectic or sintering temperature is 1300°C. Range between sintering and melting is 400°C.

Consider Fig. 6. Ternary eutectic, 33.33% A, 33.33% B, 33.33% C, melting at 1100°C. Composition *S* melts completely at 1700°C. Eutectic or sintering temperature is 1100°C. Range between sintering and melting is 600°C.

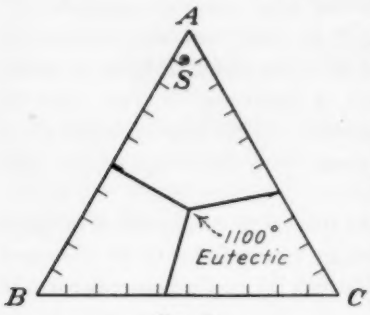

FIG. 6.

From the foregoing it is obvious that it is possible to widen the firing range slightly by increasing the number of constituents, maintaining the refractoriness, or rigidity by decreasing the total amount of these constituents. The impurities in a mineral usually cause a sintering action to take place during firing below the temperature at which chemical action of the theoretically pure mineral should normally take place. For instance, alumina is usually present in an otherwise pure talc. A very small amount of this would permit sintering at 1345°C. See Fig. 2.

Iron bearing impurities are quite common. Unfortunately there are no equilibrium studies available from which we could draw conclusions regarding the behaviors of talc or talc-clay mixtures when these iron-bearing impurities are present. Their presence, however, undoubtedly somewhat lowers the sintering and fusion temperature. This is also true if sodium and potassium bearing minerals are present as impurities.

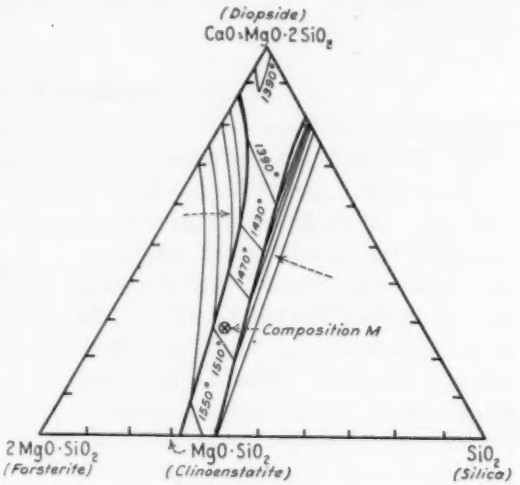

FIG. 7.

The effect of lime (CaO) upon the firing behavior of talc, and clay-talc bodies can be studied in these systems:

Ferguson & Merwin, "The Ternary System Lime–Magnesia–Silica," *Amer. Jour. Sci.*, **48,** 1919.

N. L. Bowen, "The Ternary System Diopside–Forsterite–Silica," *Amer. Jour. Sci.*, **38,** 1914.

Olaf Anderson, "The Ternary System Anorthite–Forsterite–Silica," *Amer. Jour. Sci.*, **39,** 1915.

Tables I and II show no talc containing more than 3.7% CaO. Twells,[1] however, used a commercial talc containing 7% CaO. If this talc were pure otherwise, it would probably have composition of talc 87.5, $CaCO_3$ 12.5, and when fired would analyze MgO 30.89, CaO 7.75, SiO_2 61.35.

The mineral composition of the above after equilibrium had been attained by heating sufficiently, would be diopside ($CaO.MgO.2SiO_2$) 29.9, forsterite ($2MgO.SiO_2$) 44.2, silica (SiO_2) 25.9.

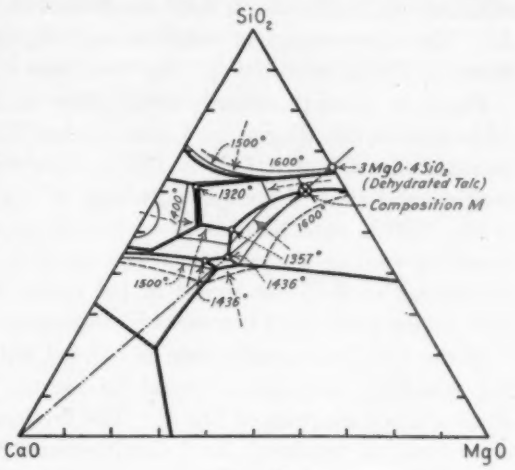

FIG. 8.

The introduction of CaO through talc into a clay-talc mixture involves a four-component system. For this reason, the low melting mixtures referred to in our use of the anorthite–forsterite–silica system may not be the first to form in the $MgO–CaO–Al_2O_3–SiO_2$ system produced by mixtures of clay, talc and calcium carbonate. The lowest eutectic of the lime–alumina–silica system is itself lower than those in the anorthite–forsterite–silica system. We would therefore expect the eutectics of the $CaO–MgO–Al_2O_3–SiO_2$ system to be even lower than those of the three-component systems. However, since the compositions fall upon the anorthite-forsterite-silica diagram, and there would be some tendency for equilibrium to be established as soon as the four-component eutectic forms during firing, it is probable as firing proceeds that the stable phases of the anorthite–forsterite–silica

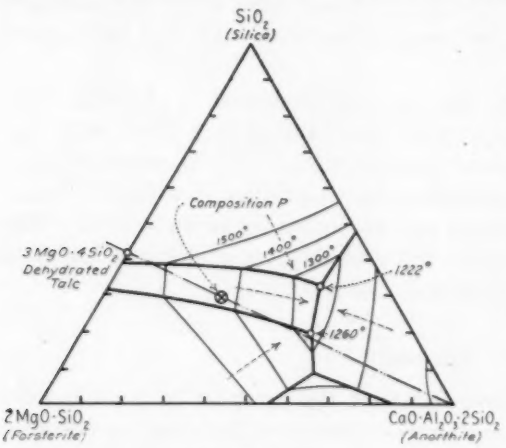

FIG. 9.

[1] R. Twells, "Further Studies of Porcelain Glazes Maturing at High Temperatures," *Jour. Amer. Ceram. Soc.*, **6** [11], 1113 (1923).

system will crystallize from this first-formed phase. This will place the compositions in the systems indicated.

Figure 7 shows the diopside–forsterite–silica ternary system. The aforementioned talc mixture on this ternary system is designated as composition *M*. The temperature of complete melting of composition *M* is approximately 1500°C, or about 50° less than that of pure talc (see Fig. 1).

Figure 8 shows the ternary system lime–magnesia–silica and composition *M* located on this diagram. Upon heating this material alone, the 1320°C eutectic forms first. This is 180°C between the temperature of first melting and that of complete melting of the mixture. There is 24.21% of the 1320°C eutectic present in this composition and therefore 24.21% liquid as soon as the eutectic temperature is reached. With such a high percentage of fluid one would be led to believe that deformation would soon follow with slight increase of temperature.

If the 7% CaO-bearing talc is bonded with clay in correct proportion the resulting composition could be located on the anorthite-forsterite-silica ternary diagram of Fig. 9. The broken line of this diagram may be considered to represent fired compositions which could be compounded from lime-bearing talcs and clay. It is implied that the clay percentage is such as to keep the lime-alumina ratio as it occurs in anorthite, namely 1:1. The addition of more than this amount of clay will not permit of the study of its effect by the use of this diagram due to the fact that the additional amount of alumina added thereby would throw the composition from the ternary diagram. The addition of only silica would not eliminate it from the diagram and therefore compositions to which it had been added could be studied.

Bonding a 7% CaO talc with clay in suitable amount to place the composition on the broken line gives raw lime-bearing talc 75.6, raw clay 24.4, or after firing, dehydrated talc ($3MgO.4SiO_2$) 70.6, anorthite ($CaO.Al_2O_3.2SiO_2$) 29.4. This is represented by composition *P* of Fig. 9. It begins to melt at 1222°C and passes entirely into a liquid at 1425°C. The high percentage of eutectic present will probably cause deformation soon after the eutectic temperature has been reached.

Summary

It would seem from the foregoing that the prospect of bonding talcs with clay and firing the resulting compositions to vitrification is a doubtful possibility except under particularly good conditions of temperature control. Apparently, however, there seem to be possibilities in compositions lying in the forsterite field. In that field the solubility of forsterite with given increases in temperature is slight as will be noted from the steepness of the slope of the solid model and due also to the high melting point of the

mineral itself. The addition of MgO to talc by some suitable method will, of course, effect this change in composition toward the forsterite composition. The least amount of clay which the method of molding will permit will also effect the same improvement in firing behavior by placing the resulting composition closer to that of forsterite.

The presence or addition of small amounts of various RO constituents will also help lengthen the firing range of these bodies.

AN X-RAY STUDY OF CYANITE AND ANDALUSITE[1]

By John T. Norton[2]

ABSTRACT

Samples of cyanite and andalusite have been examined by the X-ray diffraction method, and it has been found that the structures of these two compounds are different from one another and from sillimanite. Upon heating, the compounds are converted into another form which gives the diffraction pattern of mullite or sillimanite.

Sillimanite, cyanite and andalusite are of importance in the ceramic industry because of their conversion on firing to a compound known as mullite or artificial sillimanite. This compound has some very useful properties and the conditions which govern its formation are of interest. Previously,[3] the author has described the X-ray examination of sillimanite which indicated that the artificial compound gave a diffraction pattern which was identical with that of natural sillimanite. It was the purpose of the present investigation to examine cyanite and andalusite in the same way and to determine the temperatures at which the change in structure takes place, provided such a change could be detected.

The arrangement of lines of an X-ray diffraction pattern is characteristic of the material which produces it and in this work the diffraction pattern has been used to identify the principal crystalline constituent of the sample.

Method

The method of obtaining the diffraction patterns was similar to that employed in the previous work on sillimanite. It is the method devised by Hull,[4] and consists in mounting the sample in the form of a fine powder in the path of a monochromatic beam of X-rays, recording the pattern of lines on a photographic film. The method of mounting the samples was improved by grinding with water in a power mortar for several hours, drying, mixing with a binder such as glue or collodion and mounting in a narrow strip on the edge of a card. This procedure resulted in much clearer and sharper patterns than had been obtained before. The process of wet grinding did not introduce any uncertainty as to the composition of the sample because wet and dry ground samples gave exactly the same patterns. By wet grinding, however, it was possible to obtain a sample of the necessary fineness in a much shorter time than by the dry method.

In the cases where the samples were heated, the raw material was ground and placed in a small carbon boat in a carbon tube resistance furnace.

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[1] Recd. Aug. 10, 1925.

[2] Assistant Professor of Physics, Massachusetts Institute of Technology.

[3] Norton, "An X-ray Study of Natural and Artificial Sillimanite," *Jour. Amer. Ceram. Soc.*, **8** [7], 401 (1925).

[4] Hull, "A New Method of X-ray Crystal Analysis," *Phys. Rev.*, **10**, 661 (1917).

The temperature, which was measured with a thermocouple below 1000°C and with a Leeds and Northrup optical pyrometer above, was brought up to the desired point slowly and held there until the sample was heated uniformly throughout. Since the samples were of less than a gram in most cases, this did not require more than a few minutes. The samples were then taken out of the furnace, quenched rapidly in air, ground up with water and mounted. In the neighborhood of the transformation point, the samples were taken out of the furnace every 100°C and it seems certain that the error in measuring the temperature was less than 25°C.

Results

The diffraction patterns obtained from raw cyanite and andalusite are quite different both as regards the position of the various lines and their relative intensity. Upon heating, the patterns which are characteristic of the raw materials are changed, the change, in the case of andalusite, taking place at 1600°C and in the case of cyanite at about 1450°C. The patterns obtained from samples of the two compounds heated above these

TABLE I

SPACINGS OF DIFFRACTION PATTERNS

Andalusite (below 1500°C)		Cyanite (below 1400°C)		Andalusite (above 1700°C)		Cyanite (above 1500°C)	
Spacing (Å. U.)	Intensity	Spacing (Å. U.)	Intensity	Spacing (Å. U.)	Intensity	Spacing (Å. U.)	Intensity
3.45	medium	3.30	strong	3.45	strong	3.45	strong
2.71	strong	3.14	strong	2.90	faint	2.91	faint
2.44	strong						
2.32	very faint	2.95	very faint	2.72	medium	2.72	medium
2.24	strong	2.68	medium	2.56	medium	2.57	medium
2.14	strong	2.50	medium	2.44	faint	2.44	faint
1.95	very faint	2.33	strong	2.30	faint	2.31	faint
1.83	very faint	2.16	faint	2.21	strong	2.22	strong
1.78	medium	1.95	medium	2.13	medium	2.13	medium
1.57	faint	1.91	medium	1.89	very faint	1.89	faint
1.52	medium	1.75	faint	1.84	faint	1.85	faint
1.47	strong	1.66	faint	1.70	medium	1.71	medium
1.38	medium	1.57	faint	1.60	medium	1.60	medium
1.33	very faint	1.50	faint	1.53	strong	1.53	strong
1.28	faint	1.47	faint	1.48	very faint		
1.23	medium	1.37	strong	1.45	very faint	1.45	faint
1.20	faint	1.33	medium	1.40	very faint	1.40	very faint
1.18	faint	1.29	very faint	1.34	faint	1.34	medium
1.07	very faint	1.25	very faint	1.27	faint	1.27	medium
				1.24	faint	1.24	very faint
1.02	faint	1.18	faint	1.19	faint	1.19	faint
		1.09	very faint	1.10	faint		
1.00	faint	1.06	very faint	1.01	very faint	1.10	faint
.98	faint	1.00	very faint			1.01	faint

temperatures were all alike and are identical with the patterns obtained from sillimanite and from the artificial compound which has been called mullite by Bowen and Greig.[1] In the case of cyanite the mullite pattern appears at 1500°C, while in the case of andalusite, the 1600°C sample shows a practically complete set of lines of both patterns and the 1700°C sample shows the mullite pattern alone. In Table I are shown the atomic spacings corresponding to the diffraction lines. Figure 1 shows the diffraction patterns drawn to scale, the height of the line indicating its intensity. These are average values from a number of films. Figure 2 shows some of the actual patterns.

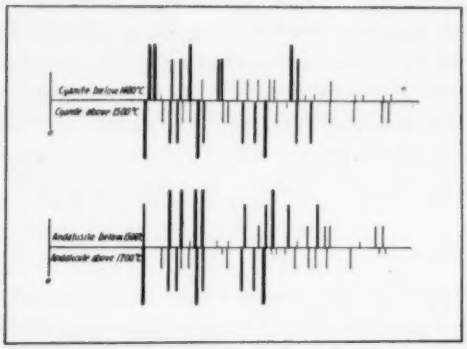

FIG. 1.—Plot to scale of spacings in Table I. The height of the lines is a measure of their intensity.

Conclusions

The X-ray examination of cyanite and andalusite has shown that in the natural form, these two compounds have a different structure, that is, a different arrangement of atoms. It has not been possible from the diffraction patterns to determine the exact arrangement because it is a more

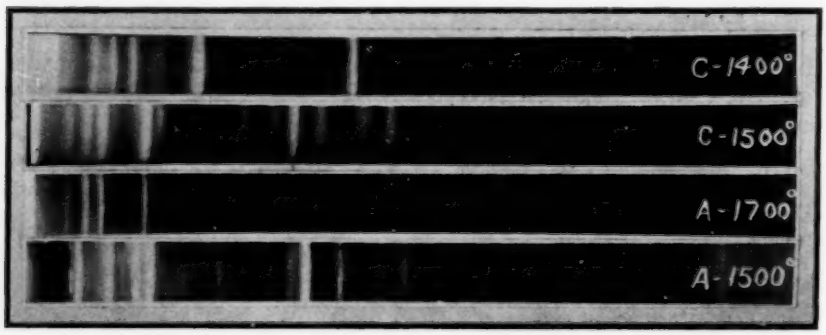

FIG. 2.—Diffraction patterns of andalusite and cyanite showing the change in form.

or less complicated one but the fact that there is a definite difference in structure is in accord with the results of optical crystallography. The examination also shows that there is a third crystalline form into which

[1] Bowen and Greig, "The System Al_2O_3–SiO_2," *Jour. Amer. Ceram. Soc.*, 7 [4], 238 (1924).

cyanite and andalusite can be converted by heating, the cyanite changing between 1400°C and 1500°C and the andalusite between 1500°C and 1700°C. This agrees with the results of Peck[1] except that his conversion temperatures, as measured with cones, are somewhat lower. This third compound gives an X-ray diffraction pattern which is identical with that given by sillimanite and by the artificially prepared compound of alumina and silica which has been called mullite. It does not seem to have been definitely established whether these two compounds are the same or not, but in any case the high temperature form of cyanite and andalusite may be considered the same as the compound formed by heating mixtures of alumina and silica, whatever its name may be. The conclusions may be briefly summarized as follows.

1. Cyanite and andalusite as they occur in nature have different crystal structures.
2. On heating, these two compounds are converted into a third form which is identical with artificial sillimanite.
3. Cyanite is converted at a temperature of about 1450°C and andalusite at 1600°C.

The use of the X-ray diffraction method for identifying the crystalline components of a mixture is becoming quite important, particularly in cases where optical and chemical methods fail to distinguish between dissimilar forms. Since the positions of the diffraction lines are determined by the arrangement of the atoms, the pattern is not affected by accidents in the growth of the crystal. It may be considered as a method of chemical analysis which not only identifies the materials of the compound but also their state of combination. While the method is comparatively new and not very extensively used at present, it is hoped that by applying it to problems of this sort, particularly in cases where there is more or less information from other sources, it may be developed to the point where it can be generally applied.

In conclusion, the writer wishes to acknowledge the kindness of J. L. Gillson of the department of Geology in supplying the samples and the assistance of E. R. C. Ward during the investigation.

[1] Peck, "Changes in the Constitution and Microstructure of Andalusite, Cyanite and Sillimanite at High Temperatures," *Jour. Amer. Ceram. Soc.*, **8** [7], 407 (1925).

DIFFERENTIATION BETWEEN MULLITE AND SILLIMANITE BY THEIR X-RAY DIFFRACTION PATTERNS[1]

By Louis Navias[2] and Wheeler P. Davey[3]

ABSTRACT

Natural sillimanite, mullite prepared by fusing alumina and silica, and calcined china clays and ball clays have been examined by the X-ray diffraction method. Each photographic film contained on one half the pattern of mullite as the reference substance, and on the other half the pattern of one of the other materials. In this manner direct comparisons of the patterns were made. It is definitely concluded that, while the patterns of sillimanite and mullite resemble each other very closely, there are pronounced differences in the positions of certain lines, especially in the region of 2.12 A to 1.70 A, sufficient for differentiation and identification. It is further concluded that the crystalline phase of highly calcined china clays and ball clays consists of mullite and not of sillimanite.

It is already well known that, although mullite and sillimanite differ considerably from each other in chemical composition, their crystals are very similar, differing mainly in optical properties. Bowen and Greig[4] have described the optical properties of the compound $3Al_2O_3.2SiO_2$ produced artificially in their laboratory by fusing alumina-silica mixtures, while Bowen, Greig and Zies[5] have described the properties of a natural mineral having the composition $3Al_2O_3.2SiO_2$ and termed by them "mullite." The crystals are identical in general chemical composition and in optical properties. The properties as given by these authors are given in Table I. Since the beginning of the year we have been working on the

TABLE I

PROPERTIES OF MULLITE AND SILLIMANITE

		Mullite	Sillimanite
Crystal system		Orthorhombic	Orthorhombic
Prism angle (1 1 0 ∧ 1 $\bar{1}$ 0)		89° 13′	88° 15′
Cleavage		‖ 0 1 0	‖ 0 1 0
Optical orientation		$\check{c} = \gamma$	$\check{c} = \gamma$
		$\bar{b} = \alpha$	$\bar{b} = \alpha$
Refractive indices	γ	1.654	1.677
	α	1.642	1.657
Axial angle	2V	+45°−50°	+25°

problem of the differentiation between mullite and sillimanite by their X-ray diffraction patterns and have arrived at a positive result. The work has proved all the more interesting because of two recent papers which report a negative result on the same problem.

[1] Recd. Aug. 15, 1925.

[2] Research Ceramist, Research Laboratory, General Electric Co., Schenectady, N. Y.

[3] Research Physicist, Research Laboratory, General Electric Co., Schenectady, N. Y.

[4] Bowen and Greig, *Jour. Amer. Ceram. Soc.*, **7**, 238–54 (1924).

[5] Bowen, Greig and Zies, *Jour. Wash. Acad. Sci.*, **14**, 183–91 (1924).

Bowen and Greig[1] say "....nor have we found sillimanite in ceramic wares of any kind. The crystals in these are always $3Al_2O_3.2SiO_2$. This observation would seem to be in disagreement with the X-ray analysis of porcelain made by G. Shearer.[2] He subjected natural sillimanite and a piece of porcelain to such analysis using the powder method and obtained identical spectra. However our colleague, Dr. Wyckoff, has kindly made similar powder photographs of our very pure sillimanite from Delaware Co., Pa., and also of the clear, transparent, microscopically homogeneous crystals of $3Al_2O_3.2SiO_2$ and has found that they give identical spectra. This is no place for a discussion of the significance of this observation. Suffice it to say here that the crystals contained in a ceramic ware cannot be established as sillimanite on the basis of X-ray analysis since this method fails to distinguish between that compound and $3Al_2O_3.2SiO_2$."

Norton[3] obtained diffraction patterns of natural sillimanite and of the crystal phase of the calcined products of pure kaolin and of 1:1 and 3:2 alumina and silica mixtures. His conclusions in part are "....As a result of the examination of about 50 films, it has been found that the patterns given by mixtures of pure Al_2O_3 and SiO_2 in the molecular proportions of 3:2 and 1:1 heated to temperatures from 1500° to 1850°C as well as samples of fused kaolin and other pure clays are alike and are identical with the pattern obtained from a sample of natural sillimanite from Norwich, Conn. The agreement was exact both in the position of the lines and in their relative intensities within the experimental error...The conclusion is drawn that the only compound of alumina and silica which is formed under the conditions of these experiments gives an X-ray diffraction pattern which is identical with natural sillimanite." Fortunately, Norton published some of his diffraction data. We have compared his data with ours and believe that we are in a position to point out why he (and probably the same applies to the other workers mentioned) failed to discover differences in the two diffraction patterns.

The Material and Its Preparation

Our sample of sillimanite was kindly loaned to us by Robert B. Sosman of the Geophysical Laboratory. It was originally obtained from Delaware Co., Pa., and constituted part of the sample used and described by Bowen and Greig in their paper.[1] The preparation of mullite by fusing pure silica and alumina in an arc has already been described by one of us.[4] Our sample of mullite was made in this way. In order that there might be no doubt that the sample was really mullite, a portion of the sample

[1] *Loc. cit.*

[2] Bragg, Shearer and Mellor, *Trans. Ceram. Soc.* (Eng.), **22**, 105–10 (1922–3).

[3] Norton, *Jour. Amer. Ceram. Soc.*, **8**, 401–6 (1925).

[4] Navias, *Jour. Amer. Ceram. Soc.*, **8**, 296–302 (1925).

was subjected to chemical analysis and its optical properties determined. The results are compared in Table II with Bowen and Greig's results for sillimanite and pure mullite. It is evident, therefore, that our specimens were actually sillimanite and mullite.

The technique of preparation of specimens for X-ray examination by the "powder method" has already been described by one of us.[1] After grinding, the powdered crystals were sieved through 200-mesh silk bolting cloth in accordance with the regular routine recommended.[1] This insured that the maximum "diameter" of particles was not over .006 cm. The two materials show entirely different characteristics upon grinding. Sillimanite breaks up into prisms whose length is usually about twice the width. It is easy to get particles whose sizes range downward from a maximum of .012 cm. The smaller fragments showed "square" corners. Mullite, ground to the same particle size, breaks up into granular pieces which seem to have no particular cleavage, and which show few real prisms under the microscope. As will be explained later, it was found

TABLE II

	Bowen and Greig		Navias and Davey
Composition	Sillimanite %	Pure mullite %	Mullite %
SiO_2	37.08	27.60	27.50
Al_2O_3	63.11	73.16	72.13
Fe_2O_3	.09	trace	trace
Refractive indices			
γ	1.677	1.654	1.654
α	1.657	1.642	1.641

from the diffraction patterns that the particles of mullite had a tendency to pack together in tiny "lumps" in the specimen tubes. Although the "lumps" themselves had a random orientation, the particles in each "lump" had approximately the same orientation. For this reason some of the mullite was ground to an average diameter of .001 cm. Still another portion was ground wet to an average diameter of about .0002 cm., and then annealed for 2 hours at 900–1000°C to remove any strains caused by grinding. In order to reduce the time of exposure to X-rays in taking the diffraction patterns, every specimen of sillimanite and of mullite was thoroughly mixed with an equal volume of wheat flour.[2] In the case of the finely ground mullite this had the additional advantage of making it more difficult for the crystal fragments to pack together, thus increasing the total number of orientations of crystal fragments in the specimen.

[1] Davey, *Gen. Elec. Rev.*, Aug., 1925.

[2] Because of its transparency to X-rays, the flour reduces the effective opacity of the specimen to the incident and diffracted beams. The flour is so nearly amorphous as to give no appreciable diffraction pattern of its own under the conditions of the experiment.

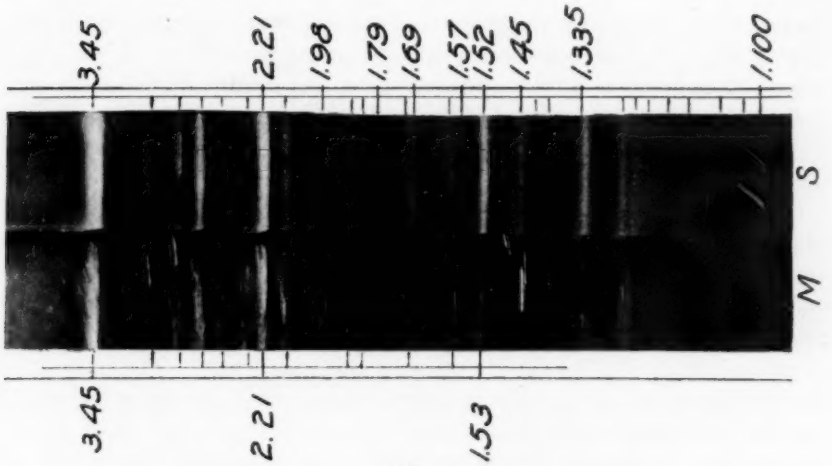

FIG. 1.

FIG. 2.

FIG. 3.

The Diffraction Patterns

Diffraction patterns of these specimens, three of which are reproduced in this report, were taken on the Standard General Electric Co. X-ray Diffraction Apparatus which has been sufficiently described elsewhere.[1] This apparatus is so designed that the diffraction patterns of two substances

[1] Davey, *Jour. Opt. Soc. Am.*, **5**, 479 (1921); *Gen. Elec. Rev.*, **25**, 565 (1922).

may be taken one above the other on the same strip of photographic film. Taking advantage of this design, our specimens were mounted with sillimanite at one end of a glass specimen-tube and mullite at the other end, so that the diffraction pattern of the mullite was always below that of the sillimanite. In this way the two patterns could be compared directly on the same film.

Figure 1 shows the pattern obtained from the sillimanite and mullite which had been ground to a maximum particle size of .012 cm. and then sieved to give a maximum particle size of .006 cm. It is a matter of ordinary experience in X-ray diffraction work that if the particle size does not exceed .006 cm. the lines of the diffraction pattern are smooth. The pattern of sillimanite in Fig. 1 is in accord with this experience. The pattern of mullite, however, has a scratchy appearance such as is characteristic of particle size considerably in excess of .006 cm. This is explained by assuming that the mullite fragments pack together in lumps such that all the particles in each lump have approximately the same orientation in one plane. Such a packing is already well known for graphite and for iodine. Figure 2 shows the pattern from another portion of the same lot of ground sillimanite (.006 cm. max. diam.) and one from mullite ground to an average size of .001 cm. The mullite lines are still scratchy but not so much as in Fig. 1. Evidently the additional grinding made it possible to produce a more chaotic orientation of the mullite fragments. Figure 3 shows a pattern from a third portion of the same sillimanite as before and a pattern of the mullite which had been ground to an average size of .0002 cm. and then annealed as described above. The mullite lines on this film were as smooth as those from sillimanite. All three films show that most of the lines from the two crystals are identical, but that certain of the lines are considerably different. Additional diffraction patterns were taken, using another diffraction apparatus in which the specimens could be rotated about the axis of the glass specimen-tube. These patterns were identical with those described above, within the experimental error.

In another connection,[1] we have taken diffraction patterns of calcined china clays and ball clays on one half of our photographic films and have simultaneously taken patterns of mullite as a comparison standard on the other half of each of the films. These films have been reviewed, and they indicate again to us that the crystalline phase of the fired clays is mullite, for in every case the pattern from the clay matches line for line with that of mullite.

Discussion of the Diffraction Data

No great precision is claimed for our measurements of the absolute values of interplanar spacings corresponding to each of the lines in the various

[1] Navias, *loc. cit.*

diffraction patterns described above. Precision measurements of these spacings require the presence, on the same film, of the pattern of a crystal, such as NaCl or calcite, whose structure and lattice parameters are accurately known. It was not our purpose to work out the structure and lattice parameters of either sillimanite or mullite but rather to search for *differences* between their diffraction patterns. For this reason we took the patterns of sillimanite and mullite *on the same film*, thus making it possible to detect *differences* between the two to a high degree of precision. Not having any calibrating pattern on these films, it is not to be expected that the interplanar distances obtained from one film will be identical with those of some other film in our series. It is to be expected, however, that if certain lines of sillimanite and mullite are (within experimental error) identical on one film they will be identical on all the films, and that if certain other lines are different on one film they will be correspondingly different on all the films. That this is actually so is brought out in Table III.[1] Of the other workers in this field, Norton[2] is the only one so far who has published numerical data. We have therefore included his data in our Table III. The published copies of his diffraction patterns are so clear and the number of films he has exposed is so great that we take it for granted that the absolute values of the interplanar distances of sillimanite, published in his article, are much more accurate than any measurements we could make on our films in the absence of a calibration

[1] The slight difference in the diffraction patterns of sillimanite and mullite was to have been expected on theoretical grounds. Table I shows that the prism angles between 1 1 0 and 1 $\bar{1}$ 0 planes of the two crystals differ by about 1°. This means that the axial ratios of the two crystals must be different. The distance L from the zero line (record of the undeviated beam) to any one line in the diffraction pattern is given by $L = \frac{\pi R}{180} \sin^{-1} \frac{n\lambda}{2d}$, where R is the radius of curvature of the film,[3] n is the order of diffraction, λ is the wave-length of X-rays employed and d is the distance between planes which give rise to the line in the diffraction pattern. d may be calculated at once by the ordinary crystallographic formula for the interplanar distance in an orthorhombic crystal,

$$d = \frac{(hx_1 + ky_1 + lz_1) - (hx_2 + ky_2 + lz_2)}{\{(h/A)^2 + k^2 + (l/C)^2\}^{\frac{1}{2}}}$$

where $h\ k\ l$ are the Miller indices of the plane, $x_1y_1z_1$, $x_2y_2z_2$ are the coördinates of successive atoms in the crystal, and A and C are the axial ratios of the crystal. It is evident that slight changes in A and C will make more change in the value of d for some planes (*i. e.*, for some values of $h\ k\ l$) than for others. Therefore the spacing L for the lines in the diffraction pattern will be more affected for some lines than for others. The region on the film where these displaced lines will appear will depend not only on h, k and l but also on $x_1y_1z_1$, $x_2y_2z_2$ and n.

[2] Norton, *loc. cit.*

[3] Davey, *Jour. Opt. Soc. Am.*, **5**, 479 (1921); *Gen. Elec. Rev.*, **25**, 565 (1922).

TABLE III

Navias and Davey							Norton		
Film 1228 (see Fig. 1)		Film 1235 (see Fig. 2)		Film 1282 (see Fig. 3)		Average difference between sillimanite and mullite	Sillimanite	"Artificial compound"	[1] Difference between sillimanite and "artificial compound"
Sillimanite	Mullite	Sillimanite	Mullite	Sillimanite	Mullite				
3.45	3.45	3.45	3.45	3.45	3.45	.00	3.45	3.44	— .01
2.89	2.88	2.92	2.92	2.92	2.92	.00	2.91	2.91	.00
2.69	2.69	2.72	2.71	2.71	2.71	.00	2.69	2.72	+ .03
2.55	2.55	2.57	2.57	2.58	2.57	.00	2.55	2.55	.00
2.43	2.43	2.45	2.45	2.44	2.45	.00	2.43	2.38	— .05
2.30	2.30	2.30	2.31	2.31	2.31	.00	2.30	[a]	[a]
2.21	2.21	2.23	2.22	2.22	2.22	.00	2.21	2.22	+ .01
2.12	2.12	2.13	2.14	2.13	2.13	.00	2.12	2.10	— .02
1.98	[a]	1.99	[a]	1.99	[a]	[a]			
1.87[5]	1.89	1.88[5]	1.91	1.88	1.91	+ .02			
1.83	1.84[5]	1.84	1.85	1.84[5]	1.86	+ .01			
1.79	[a]	1.80	[a]	1.80	[a]	[a]			
1.71	1.70[5]	1.71[5]	1.71	1.71[5]	1.71[5]	.00	1.70	1.72	+ .02
1.69	[a]	1.69[5]	[a]	1.69[5]	[a]	[a]			....
1.60	1.59	1.61	1.60	1.60[5]	1.60	— .01	1.60	1.61	+ .01
1.57	[a]	1.57[5]	[a]	1.57[5]	[a]	[a]	1.57	[a]	[a]
1.52	1.53	1.53	1.53	1.52[5]	1.53	.00	1.52	1.52	.00
1.45		1.45	1.45	1.45	1.45	.00	1.45	1.45	.00
1.42		1.42[5]	[a]			[a]			
1.39[5]		1.40	1.41		1.41[5]	+ .01?	1.38	1.38	.00
1.33[5]		1.33[5]	1.33[5]	1.33[5]	1.33[5]	.00	1.33	1.34	+ .01
1.275		1.275	1.270	1.275	1.275	.00	1.27	1.27	.00
1.255		1.255	[a]				1.25	1.24	
1.235		1.235	1.240						
1.210		1.210	[a]						
1.185		1.190	1.190				1.18	1.19	
1.145		1.145	1.145				1.14	1.14	
1.120		1.120	1.120				1.12	1.12	
1.100		1.100	1.100				1.10	1.10	
1.055							1.05	1.04	
1.033									
1.018		1.017	1.018						
1.008		1.007	1.008				1.01	1.01	
.985		.988	.989						

pattern. We have, therefore, adjusted all our readings so that our data for sillimanite correspond closely to Norton's. This was done by sliding

[1] Norton gives only the average values of a number of different films. We are therefore unable to tell whether his differences on individual films are as consistent as ours.

[a] A line was found for sillimanite but was not observed for mullite.

the films along in the scale on which interplanar distances were read until one of our lines (the 2.12) matched Norton's reading for the same line, as recorded in his article. This facilitates comparison between his data and ours. Spacings smaller than 1.90 A were determined to the nearest 5 in the third decimal place. It will be noted at once that Norton's data show no lines at all in the region (2.12 A to 1.70 A) where we find our most striking differences between sillimanite and mullite. We are inclined to think that his failure to obtain these lines must have been due to the packing effect mentioned above. Probably grinding to a smaller particle size and longer exposure time would have enabled him to get the additional lines. Since he worked with calcined clays, it is of interest to note that when sufficient exposure was given every one of our diffraction patterns of calcined clays mentioned above shows the characteristic lines of mullite (not of sillimanite) in the region between 2.12 A and 1.70 A. This is consistent with the chemical and optical data of Bowen and Greig.[1]

Conclusions

(1) We have shown that the X-ray diffraction patterns of pure sillimanite and pure mullite are different.

(2) We have shown by purely X-ray methods that the crystalline component of calcined clays is mullite, not sillimanite. These conclusions are in accord with chemical and optical data to be found in the literature, but are not in accord with the negative results previously reported by several workers in X-ray crystallography.

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[1] Bowen and Greig, *loc. cit.*

THE RELATION OF STRUCTURE AND COMPOSITION TO THERMAL EFFICIENCY OF REFRACTORIES WHEN USED IN REGENERATORS[1]

By Stuart M. Phelps[2]

ABSTRACT

This study shows the relative rates of heat transmission in typical clay, silica, diaspore, fused alumina and silicon carbide refractories, when used as checker brick.

It is shown that by lowering the porosity of checker brick an increase in efficiency is obtained by virtue of its greater heat capacity, which is a function of the weight and specific heat of the material.

The glazing of a clay brick does not appreciably impair its efficiency in regeneration, as is sometimes thought, as shown by experiment and as explained by the fact that the greatest part of the heat leaves the surface of the brick by convection and this is affected only by the surface area, which is not appreciably changed by glazing.

Introduction

There is need of information on the type of fire clay refractories having highest thermal efficiency as regenerator checker brick. Data of this nature on refractories of other compositions is useful, especially when obtained under the same experimental conditions.

Relative Rates of Heat Flow

To calculate thermal efficiencies, it is necessary to determine relative rates of heat flow. A 9-inch brick was heated to a surface temperature of 2300°F and as uniformly throughout as possible. It was then cooled with a constant amount of air passing over it and the temperatures at the surface and center recorded at small time intervals. The mean temperature of the brick at any given time during the cooling was assumed to be the average of the temperatures at the surface and center at that instant. This assumption was necessary since the scope of this investigation could not include the laborious determinations required to give the true mean temperature at any instant during the cooling period. However, this procedure should give relative and essentially accurate information for the various refractories. Using this mean temperature, the specific heat (at this temperature) and the weight of the brick, the relative B.t.u. contents were calculated. In this manner the comparative efficiencies of the refractories when used for regenerators were obtained.

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[1] Presented at the Organization Meeting of the American Refractories Institute held at Mellon Institute of Industrial Research, University of Pittsburgh, Pittsburgh, Pa., April 14, 1925.

[2] Industrial Fellow, Refractories Fellowship, Mellon Institute of Industrial Research.

Equipment and Procedure

A diagram of the furnace used for this work is shown in Fig. 1.

The sample was placed upon checker work. The temperatures were recorded by a potentiometer recorder. The furnace was heated until the surface of the brick was 2300°F and then held at that heat until the temperature of the center of the brick was only slightly below that of the surface. The cooling period was then started by introducing, through the burner pipe, a constant amount of cool air, supplied by a separate motor blower unit. The experimental error of this procedure was small as shown in Fig. 2, where five cooling curves on a single sample of clay brick are plotted.

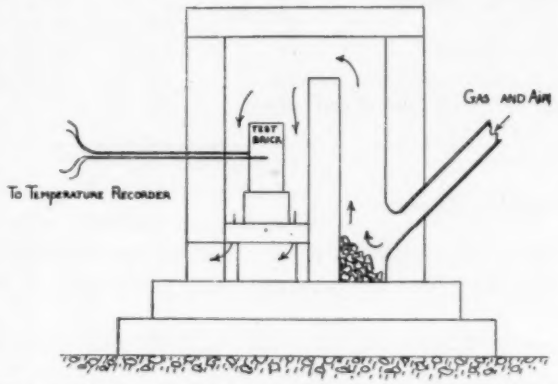

Fig. 1.—Furnace used to study the relative rate of heat flow in refractories.

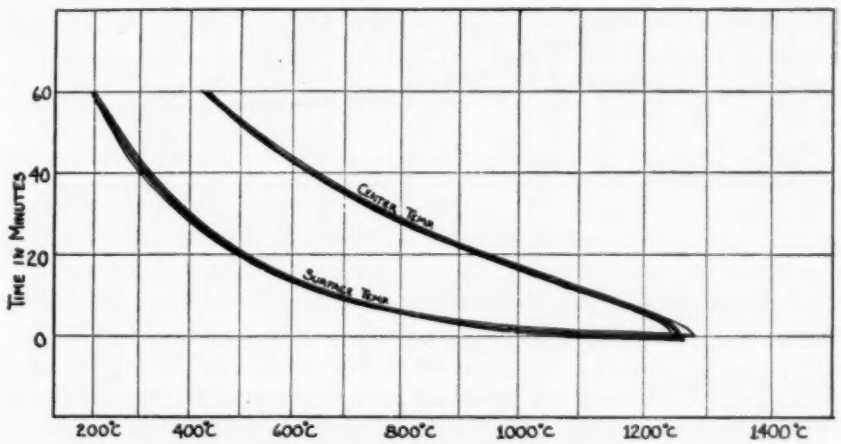

Fig. 2.—Graph showing the experimental error in five runs of a fire clay brick.

Refractories Tested

Some of the properties of the various refractories investigated are given in Table I.

TABLE I

Material	Pounds per cubic foot	Per cent porosity	Silica	Alumina	Lime
A—Clay, low porosity	124.2	13.8	51.68	40.17	
B—Clay, dry pressed	124.4	17.3	50.32	42.95	
C—Clay, high porosity	116.4	25.8	56.28	39.52	
D—Clay, siliceous	113.2	30.5	76.84	19.18	
E—Silica	100.5	27.8	95.20		1.75
F—Diaspore	124.5	36.0	16.60	78.30	
G—Electrically fused alumina	182.0	18.50			
H—Recrystallized silicon carbide	131.2	31.6			

Data Obtained

Cooling Curves

In Fig. 3 the cooling curves for all of the samples tested are plotted. The surface temperatures during cooling show little variation except in the case of silica and silicon carbide. The temperatures at a given time in the center of the several

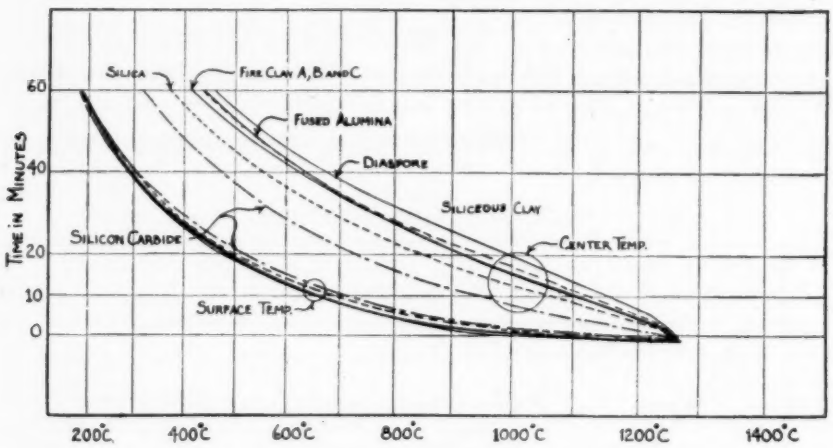

FIG. 3.—Average cooling curves for various brick.

brick show considerable variation due to the different thermal conductivities and different quantities of heat stored in the brick.

Heat Released on Cooling

The amount of heat contained in a brick at a given temperature is determined by its weight and the specific heat at that temperature. Specific heats for silica and clay refractories have been determined by Bradshaw and Emery,[1] for silicon carbide by O. Weigel,[2] and for fused alumina by Regnault.[3] These specific heats are plotted in Fig. 4. Using these spe-

[1] Bradshaw and Emery, *Trans. Ceram. Soc.* (Eng.), **19**, 88 (1919–20).

[2] O. Weigel, "Treatise on Inorganic Chemistry," J. W. Mellor, vol. **5**, p. 880.

[3] Regnault, Landolt Boernstein.

cific heats, and assuming that the siliceous sample *D*, and the diaspore *F*, to be of the same specific heats as silica or clay, and silicon carbide to be approximately 0.08 at 2300°F, the following table of B.t.u.'s given up during the cooling period was calculated from the mean temperatures obtained by the use of the cooling curves shown in Fig. 3. These calculations were made in each case for a single 9-inch brick—9 x 4.5 x 2.5—the results of which are plotted in Fig. 5 and are presented in Table II.

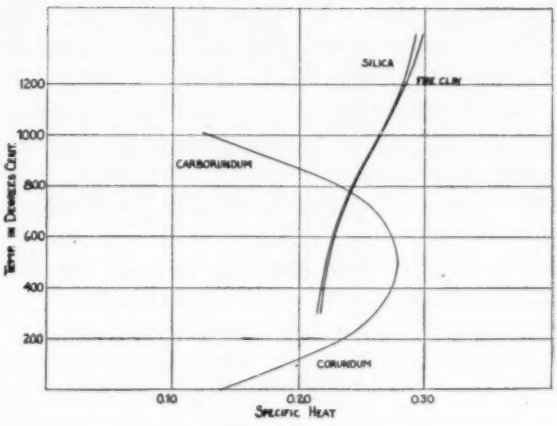

FIG. 4.

There is a considerable difference in the amounts of heat given up by the various brick during cooling, as shown by these data. Such difference in efficiency would be very important in a practical installation using hundreds of such brick as checkers. This difference in efficiency is due, principally, to the different quantities of heat that can be stored in a given volume of the refractories and the speed at which it can be conducted to the surface.

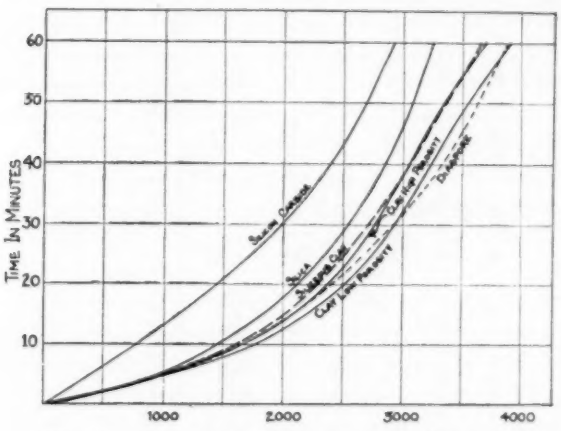

FIG. 5.—B.t.u.'s per brick given up during cooling.

Comparing the three clay samples *A*, *B* and *C*, it will be noted that sample *B* has the greatest weight per brick, *A* coming next and *C* the lowest. As the specific heat of these clay brick is the same, it is evident that for a given temperature the B.t.u.'s held by these materials will be of the same order as their bulk density. Furthermore, as the cooling curves for all three clay bricks were identical, this same order holds for B.t.u.'s given up during cooling. During a given period *A* or *B* give up a greater quantity

TABLE II

Material	Pounds per brick	B.t.u.'s in the brick at 1260°C (2300°F)	Temperature and B.t.u.'s given up during cooling from 1260°C (2300°F) 10 Min.	20 Min.	40 Min.	60 Min.
A—Clay, low porosity	7.33	4840	885° C(1625°F) 1740	702°C (1295°F) 2510	505°C (941°F) 3245	300° C (572°F) 3935
B—Dry-pressed clay, medium porosity	7.35	4860	885°C (1625°F) 1760	702°C (1295°F) 2530	505°C (941°F) 3264	300°C (572°F) 3956
C—Clay, high porosity	6.87	4540	885°C (1625°F) 1640	702°C (1295°F) 2360	505°C (941°F) 3050	300°C (572°F) 3700
D—Clay, siliceous	6.88	4550	895° C(1643°F) 1600	717°C (1322°F) 2270	505°C (941°F) 3050	315°C (600°F) 3660
E—Silica	5.93	3920	865°C (1589°F) 1480	675°C (1247°F) 2120	425°C (797°F) 2850	280°C (536°F) 3240
F—Diaspore	7.35	4850[1]	910°C (1670°F) 1650[1]	735°C (1355°F) 2380[1]	490°C (914°F) 3310[1]	320°C (608°F) 3880[1]
H—Recrystallized silicon carbide	7.74	3630	825°C (1517°F) 750	625°C (1127°F) 1480	385°C (725°F) 2400	252°C (485°F) 2910

[1] Calculations made by assuming the specific heat of diaspore to be the same as that of clay.
The data given above are for a 9 x $4^1/_2$ x $2^1/_2$-inch brick in each case.

of heat than *C*, which can occur only by virtue of a higher thermal conductivity in the case of *A* or *B*. Such a difference in heat transfer may be explained by the findings of A. T. Green,[1] who has shown that pores of a certain size act, within a given temperature range, as insulators. This subject is also discussed by Calvert and Caldwell.[2]

Glazed Surface of Checker Brick Not Detrimental

An interesting experiment was conducted with the high porosity brick *C*, in which the brick was completely glazed in such a manner as to give a thin, smooth, glassy surface. On comparing the cooling curves of this brick in its original condition, and after being glazed, it was found that they were identical. This is to be expected, since a very large quantity of the heat was given up by convection from the surface of the brick. The function of convection is not appreciably affected under such conditions by changing the nature of the surface of the brick by glazing it, since the surface film is substantially of the same area before and after glazing. Accordingly, it may be assumed that the glazing of checkers in a regenerator does not impair their thermal efficiency.

Comparison of Silica and Clay as Checkers

The siliceous clay sample *D* is a somewhat less efficient checker brick than the clay bricks *A* or *B*, the explanation of which may be, as pointed out above, the high porosity of this material.

Rapid cooling is shown by the curve obtained from the silica brick *E*, which is to be expected in view of the comparatively small number of B.t.u.'s stored in this brick at 2300°F and the relatively high thermal conductivity attributed to it by practical men. By reason of their low bulk density, silica brick have a comparatively small heat capacity, thus making them less suitable for checker brick than clay brick.

No information is available regarding the specific heats of diaspore, so little can be said regarding sample *F*. However, with its high porosity and lagging cooling curve, it might be expected that this material has a low thermal conductivity, provided its specific heat is approximately that of clay.

Specific heats for electrically fused alumina have not been determined at high temperatures and the order of its thermal conductivity is a matter of controversy, so nothing definite can be said regarding the behavior of this refractory in regenerators. This material has approximately the same specific heat at 100°C as that of clay, and, provided it follows the same characteristic as clay at higher temperatures, it would make an efficient checker brick, as its cooling curve is substantially that of clay, but possesses a very high bulk density, allowing it to store a greater quantity of heat.

[1] A. T. Green, *Gas J.*, Supp., July 9 (1925).

[2] Calvert and Caldwell, *Ind. Eng. Chem.*, **16** [5], 483 (1924).

Silicon Carbide of Little Value for Checkers

Recrystallized silicon carbide possesses a high thermal conductivity and a low specific heat. By virtue of this high conductivity, this material cooled rapidly, especially as it contained a relatively small quantity of heat to be dissipated. For checker work, brick of this composition would be of little value, except in an operation where rapid reversal of the regenerators would be desirable.

Summary

1. The usefulness of fundamental data, such as the specific heats of fused alumina and diaspore at high temperatures, is evident.

2. Silicon carbide possesses a combination of high thermal conductivity, but low thermal capacity.

3. Silica brick have, by virtue of their low apparent density, a low thermal capacity, making them less suitable for checkers than clay brick.

4. Great differences in regenerator efficiency can be had by the use of clay brick of varying porosity. The denser the brick, the more efficient it is in checker work operation. Fortunately such brick are more resistant to slag action than those of more open structure, have less shrinkage in service, and do not deform under load as readily.

Acknowledgment

The author wishes to thank M. C. Booze for the helpful suggestions given during this investigation.

THE CHEMICAL AND PHYSICAL PROPERTIES OF FIRE CLAYS FROM VARIOUS PRODUCING DISTRICTS[1]

By M. C. Booze[2]

ABSTRACT

The chemical analyses, fusion points and firing characteristics of a number of flint and plastic clays from various districts are given, together with a short discussion of the results and the use which can be made of them.

Clays were tested for chemical composition, fusion point, drying and firing shrinkage, and fired porosity. The methods of tests given in the 1922 report of the AMERICAN CERAMIC SOCIETY Committee on Standards were closely followed in each case, except that the dry volumes of the test pieces were determined according to the method recommended by Crawford.[3]

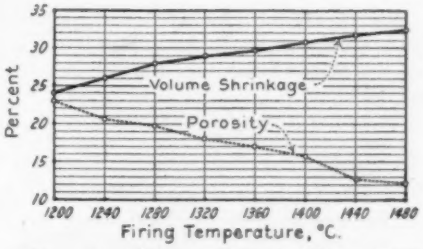

FIG. 1.—Firing characteristics. Raw smooth flint clay, Missouri. Fusion point, cones 32–33.

Both the flint and plastic clays may be divided into open and dense firing groups. A further classification of the dense burning plastic clays is possible by separating those which overfire from those which do not. The property of overfiring is largely limited to the plastic clays, only one of the flint clays (Fig. 25) giving evidence of this and then not to a pronounced degree.

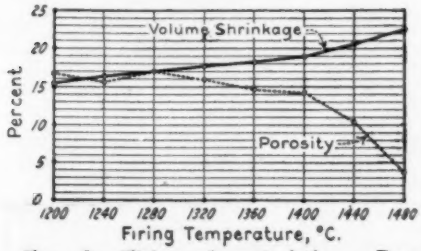

FIG. 2.—Firing characteristics. Raw Cheltenham clay, Missouri. Fusion point, cones 30–31.

There is no relation between chemical composition or fusion point and the property of being open or dense burning. The two most open burning plastic clays (Figs. 16 and 19) have silica contents of 44% and 76%, and fusion points of cones 32–33 and cone 30, respectively, while the plastic clays which burn dense and then overfire vary within almost the same limits. The

[1] Presented at the Annual Meeting of the AMERICAN CERAMIC SOCIETY, Columbus, Ohio, Feb., 1925.

[2] Senior Industrial Fellow, Multiple Industrial Fellowship of the Refractories Manufacturers Association, Mellon Institute of Industrial Research, University of Pittsburgh, Pittsburgh, Pa.

[3] "A Simplified Method of Determining the Dry Volumes of Clay Briquettes," *Jour. Amer. Ceram. Soc.*, **5**, 394 (1922).

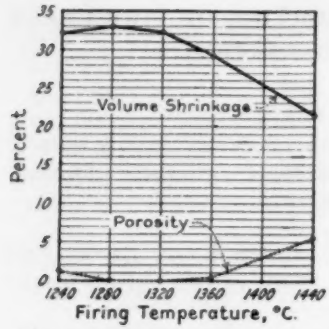

FIG. 3.—Firing characteristics. Raw plastic clay (B 291), Missouri. Fusion point, cone 32.

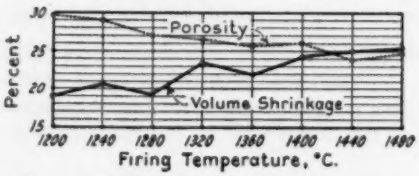

FIG. 6.—Firing characteristics. Raw Burley flint clay, Missouri. Fusion point above cone 33.

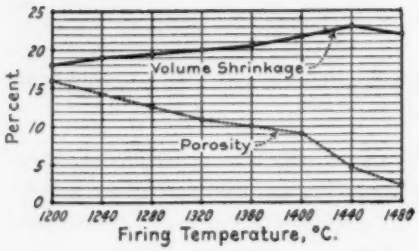

FIG. 4.—Firing characteristics. Select crude pot clay, Missouri. Fusion point, cones 30–31.

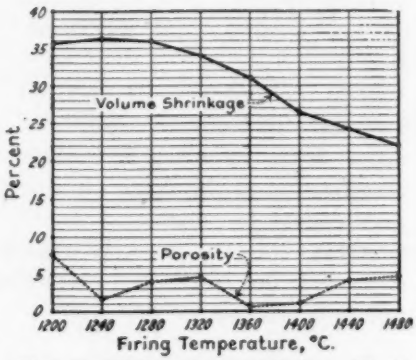

FIG. 7.—Firing characteristics. Plastic bond clay, Maryland. Fusion point, cones 31–32.

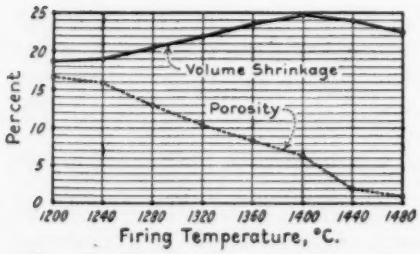

FIG. 5.—Firing characteristics. Raw plastic clay (No. 118), Missouri. Fusion point, cone 31.

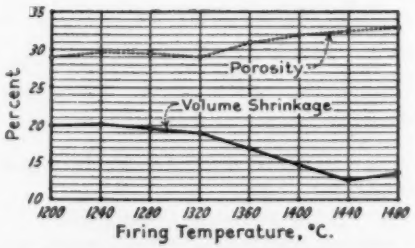

FIG. 8.—Firing characteristics. Flint clay, Maryland. Fusion point, cones 33–34.

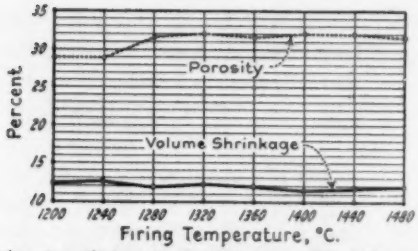

FIG. 9.—Firing characteristics. Flint clays, Colorado. Fusion point, cone 32.

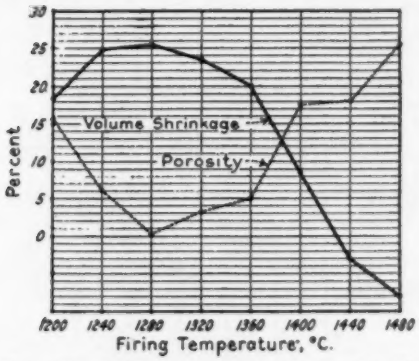

FIG. 10.—Firing characteristics. Plastic clay, Colorado. Fusion point, cone 27.

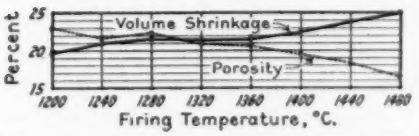

FIG. 11.—Firing characteristics. Semi-flint clay, Colorado. Fusion point, cone 32.

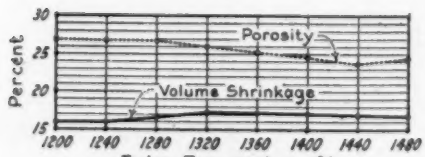

FIG. 12.—Firing characteristics. Dean flint clay, Pennsylvania. Fusion point, cones 33–34.

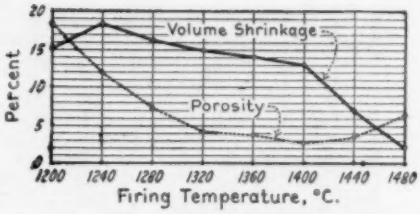

FIG. 13.—Firing characteristics. Plastic clay, Westmoreland County, Pennsylvania. Fusion point, cones 30–31.

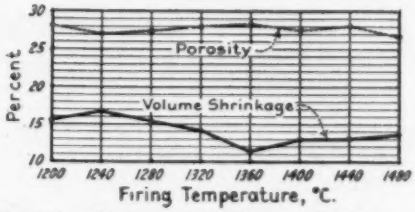

FIG. 14.—Firing characteristics. Flint clay, Clinton County, Pennsylvania.

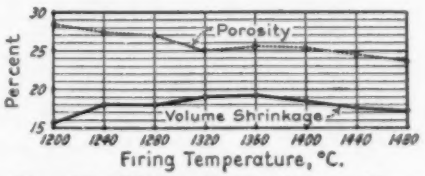

FIG. 15.—Firing characteristics. Monument flint clay, Pennsylvania. Fusion point, cones 32–33.

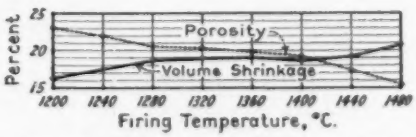

FIG. 16.—Firing characteristics. Plastic bond clay, Cambria County, Pa. Fusion point, cones 32–33.

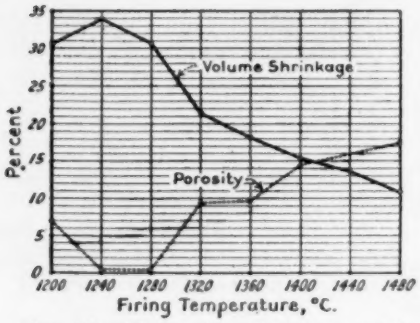

FIG. 17.—Firing characteristics. Rockingham plastic clay, New Jersey. Fusion point, cones 27–28.

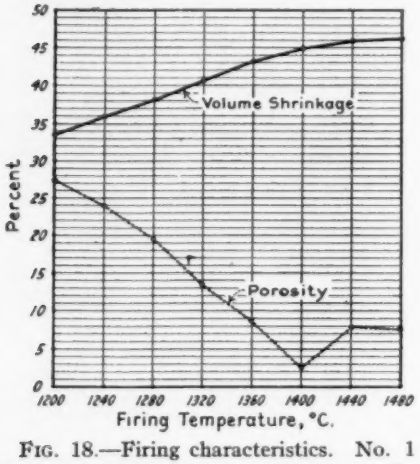

FIG. 18.—Firing characteristics. No. 1 fine clay, New Jersey. Fusion point above cone 33.

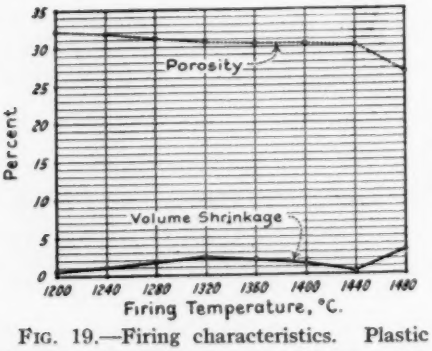

FIG. 19.—Firing characteristics. Plastic clay No. 38, New Jersey. Fusion point, cone 30.

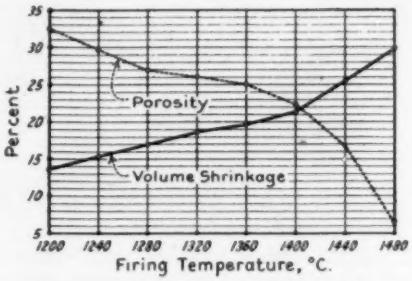

FIG. 20.—Firing characteristics. Plastic clay No. 32, New Jersey. Fusion point, cone 30.

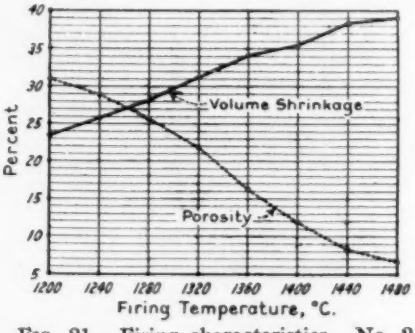

FIG. 21.—Firing characteristics. No. 2 fine clay, New Jersey. Fusion point, cones 32–33.

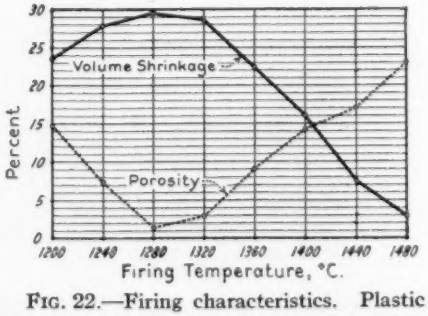

FIG. 22.—Firing characteristics. Plastic clay No. 30, New Jersey. Fusion point, cone 30.

clays in this latter group are also characterized by minimum porosities which are equal to zero in almost every case, and by comparatively high alkali contents; the range in the latter being from 0.97% to 2.60%, with an average of 1.58%, while the dense firing plastic clays which do not overfire vary from 0.12% to 0.49% with an average of 0.32%. An exception to this is the clay shown in Fig. 16, which is open firing and has an alkali content of 1.57%. The alkalis appear to have a very pronounced effect upon both the fusion point and the firing properties. An increase or decrease of ½% in a clay which is otherwise uniform can usually be detected by a change in the fusion point.

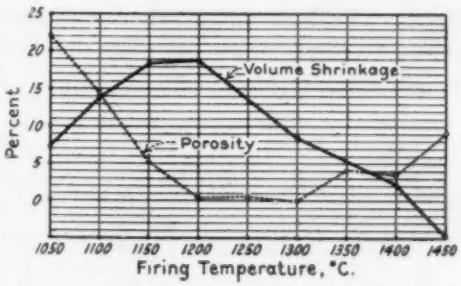

FIG. 23.—Firing characteristics. Black plastic clay, Kentucky. Fusion point, cones 20–26.

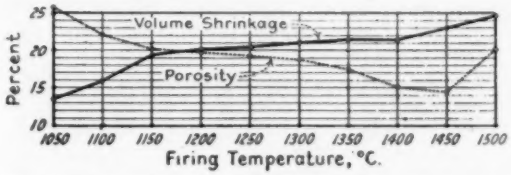

FIG. 24.—Firing characteristics. Hard semi-flint clay, Kentucky. Fusion point, cones 32–33.

As compared to the plastic clays, all of the flint clays are open burning. This may be due as much to the fact that they are not slaked down by water to a fine grain size as to their relative degree of purity. Fineness of grain in itself has an influence upon firing density as has been determined on materials entirely lacking in the plastic properties of clays. Aside from this, the flint clays are also lacking in the cohesiveness possessed by plastic materials which aids in consolidation.

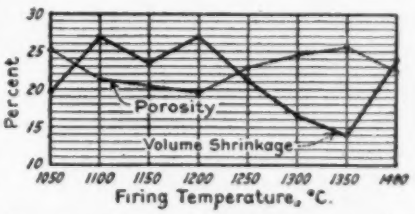

FIG. 25.—Firing characteristics. Flint clay, Kentucky. Fusion point, cone 32.

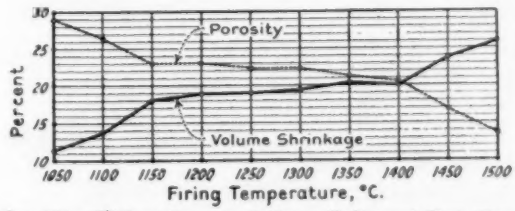

FIG. 26.—Firing characteristics. Soft semi-flint, Kentucky. Fusion point, cones 32–33.

It is difficult to make comparisons between various districts in the quality of their clays as there are no outstanding differences which separate

them. The Missouri district is generally credited with clays of higher alumina content than the other districts, but the difference is largely in amounts of these clays available. The burley flint clay of Missouri on which results are given here is matched by nodular flint clay from Pennsylvania and a high alumina flint from Kentucky.

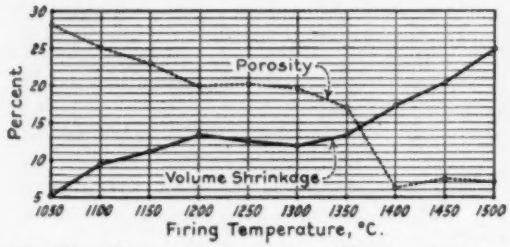

FIG. 27.—Firing characteristics. "Pink eye" plastic clay, Kentucky. Fusion point, cones 20–26.

While the New Jersey district produces no flint clay, it has a great variety of refractory materials. It is commonly supposed that all of the clays from this locality are highly siliceous, but the analyses of the No. 1 and No. 2 "fine" clays show the error of this assumption. The bulk of the refractory clays which are used in this state are low in their content of fluxes and the products owe their good load carrying capacity to this fact as much as to the incorporation of siliceous clays with the plastic bond clays.

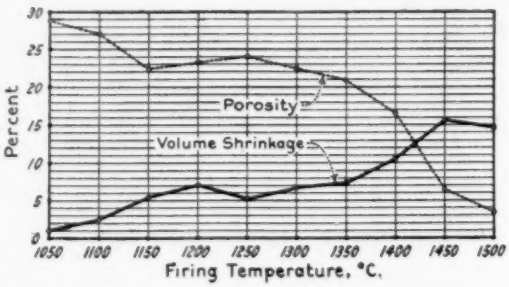

FIG. 28.—Firing characteristics. Siliceous semi-flint clay, Kentucky. Fusion point, cones 29–30.

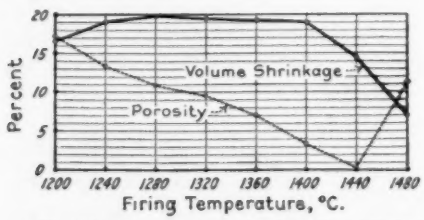

FIG. 29.—Firing characteristics. Plastic clay, southern Ohio. Fusion point, cone 28–29.

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Acknowledgment

As this paper is very largely a record of tests, the credit for it is due the various members of the laboratory staff who obtained the extensive amount of data which was necessary.

CHEMICAL ANALYSES AND FIRING PROPERTIES OF FIRE CLAYS FROM VARIOUS PRODUCING DISTRICTS

	MISSOURI DISTRICT					
Chemical analysis	Raw smooth flint clay	Raw Chelten-ham clay	Raw plastic clay (B-291)	Select crude pot clay	Raw plastic clay (No. 118)	Raw burley flint clay
Ignition loss	13.86	11.96	12.10	12.04	11.26	13.30
Silica	43.32	54.78	49.62	55.04	53.12	34.62
Alumina	39.35	28.84	33.15	28.75	31.16	48.03
Iron oxide	0.77	1.98	1.55	1.55	1.18	1.09
Titania	2.00	1.64	1.56	1.68	1.76	2.28
Lime	0.16	0.43	0.13	0.42	0.12	0.25
Magnesia	.33	.72	.93	.80	.48	.56
Alkalis	.22	.21	.97	.48	.49	.44
Total	100.01	100.56	100.01	100.76	99.57	100.57
Fusion point Cone	32–33	30–31	32	30–31	31	Above 33
Burning properties						
Water of plasticity	19.78	21.2	32.5	22.3	17.86	23.3
Drying shrinkage	9.3	22.3	32.1	25.6	14.09	11.4
Av. firing shrinkage						
1200°C	23.9	15.4	....	17.9	18.6	19.2
1240	26.2	16.2	32.7	19.1	18.9	20.6
1280	27.8	17.3	33.2	19.5	20.7	19.3
1320	29.3	17.8	32.4	20.0	22.1	23.5
1360	29.6	18.3	29.4	20.4	23.6	22.1
1400	30.8	19.0	Blew up	21.6	24.7	24.4
1440	31.6	20.8	21.85	23.2	24.2	24.9
1480	32.2	22.7	....	22.0	22.5	25.2
Av. porosity						
1200°C	23.1	16.7	....	15.9	16.6	29.7
1240	20.6	15.8	1.4	14.4	15.8	29.2
1280	19.6	17.3	0.25	12.6	13.3	27.0
1320	18.1	16.0	.3 exp.	11.0	10.5	26.6
1360	17.2	14.7	.46	10.1	8.4	25.9
1400	15.8	14.3	Blew up	9.1	6.3	26.0
1440	14.2	10.6	5.9	4.5	2.0	24.3
1480	13.9	4.0	....	2.3	1.1	25.1

CHEMICAL ANALYSES AND FIRING PROPERTIES OF FIRE CLAYS FROM VARIOUS PRODUCING DISTRICTS

	MARYLAND DISTRICT			COLORADO DISTRICT	
Chemical analysis	Plastic clay	Flint clay	Flint clay	Plastic clay	Semi-flint clay
Ignition loss	9.02	14.60	12.24	6.16	14.16
Silica	52.88	42.76	54.06	70.82	49.02
Alumina	33.61	39.15	32.05	19.43	34.78
Iron oxide	1.63	1.11	0.49	1.03	0.72
Titania	1.28	2.80	1.00	0.84	.96
Lime	0.22	0.18	0.43	.18	.39
Magnesia	.49	Trace	.25	.44	.24
Alkalis	1.39	0.23	.12	1.37	.37
Total	100.52	100.83	100.64	100.27	100.64
Fusion point Cone	31–32	33–34	32	27	32
Burning properties					
Water of plasticity	34.1	17.4	20.7	25.6	20.0
Drying shrinkage	24.8	7.3	11.1	19.3	15.0
Av. firing shrinkage					
1200°C	35.6	20.0	12.4	18.8	19.7
1240	36.4	20.1	12.8	24.9	21.1
1280	35.9	19.6	12.0	25.6	21.7
1320	34.0	19.3	12.5	23.5	21.6
1360	30.9	17.3	12.0	20.1	21.7
1400	26.3	14.6	11.6	8.7	22.5
1440	24.0	12.7	11.7	3.1 exp.	24.0
1480	22.2	13.6	12.3	8.2 exp.	25.1
Av. porosity					
1200°C	7.6	28.9	29.1	15.6	23.0
1240	1.6	29.7	28.9	6.3	21.5
1280	3.9	29.5	31.9	0.37	22.4
1320	4.8	29.1	32.0	3.3	21.0
1360	0.7	30.9	31.6	5.1	20.5
1400	1.1	32.0	32.1	17.5	19.7
1440	4.1	32.5	32.0	18.2	18.4
1480	4.5	33.0	31.6	25.5	16.7

CHEMICAL ANALYSES AND FIRING PROPERTIES OF FIRE CLAYS FROM VARIOUS PRODUCING DISTRICTS

	KENTUCKY DISTRICT					
Chemical analysis	Siliceous semi-flint clay	Soft semi-flint clay	Hard semi-flint clay	Black plastic clay	Flint clay	"Pink-eye" clay
Ignition loss	8.86	14.40	14.08	9.66	13.60	9.36
Silica	65.04	46.16	43.46	55.92	41.00	57.36
Alumina	22.29	35.04	37.45	24.71	37.22	24.85
Iron oxide	1.13	1.42	1.19	4.79	5.78	5.95

Titania	1.60	2.44	2.80	1.52	2.00	1.64
Lime	0.21	0.27	0.30	0.34	0.25	0.15
Magnesia	.47	.49	.64	1.01	.46	.71
Alkalis	1.38	.64	.93	1.57	.42	.37
Total	100.98	100.86	100.85	99.52	100.73	100.39
Fusion point Cone	29–30	32–33	32–33	20–26	32	20–26
Firing properties						
Water of plasticity	13.9	16.8	14.6	18.9	17.5	17.4
Drying shrinkage	11.9	13.0	10.8	18.8	3.0	12.8
Av. firing shrinkage						
1050°C	1.1	11.5	13.5	7.7	19.7	5.2
1100	2.6	13.7	16.1	14.0	27.0	9.8
1150	5.6	18.2	19.5	18.5	23.7	11.2
1200	7.0	19.1	20.2	18.8	27.0	13.5
1250	5.3	19.1	20.5	....	21.3	12.8
1300	6.9	19.6	21.2	8.5	16.8	12.1
1350	7.6	20.6	21.7	....	14.0	13.7
1400	10.8	20.1	22.4	2.4	27.4	17.6
1450	15.6	23.9	23.1	5.3exp.	....	20.4
1500	14.7	26.0	24.8	....	....	25.0
Av. porosity						
1050°C	28.9	29.0	25.8	22.2	25.3	28.0
1100	27.3	26.6	22.3	14.2	21.4	25.0
1150	22.8	23.3	20.0	5.3	20.4	23.1
1200	23.3	23.4	19.9	0.6	19.5	20.0
1250	24.1	22.6	19.4	.7	22.9	20.2
1300	22.8	22.5	18.7	....	24.9	19.8
1350	21.0	21.4	17.5	4.3	25.9	17.1
1400	16.7	20.5	15.0	3.6	19.3	6.5
1450	6.8	16.9	14.4	9.1	....	7.5
1500	3.7	13.5	13.5	....	....	5.4

CHEMICAL ANALYSES AND FIRING PROPERTIES OF FIRE CLAYS FROM VARIOUS PRODUCING DISTRICTS

	NEW JERSEY DISTRICT					
Chemical analysis	Rockingham clay	Plastic clay (No. 32)	No. 1 fine clay	Plastic clay (No. 38)	No. 2 fine clay	Plastic clay (No. 30)
Ignition loss	9.04	7.54	14.32	5.60	12.38	7.96
Silica	57.20	69.56	43.86	76.24	51.04	65.24
Alumina	25.78	20.34	38.81	15.76	32.31	22.34
Iron oxide	2.78	0.54	0.89	0.52	1.29	1.14
Titania	1.32	1.64	1.84	1.68	1.92	1.36
Lime	0.13	0.25	0.34	0.26	0.37	0.20
Magnesia	1.11	.30	.34	.29	.34	.79
Alkalis	2.60	.26	.31	.23	.12	1.71
Total	99.96	100.43	100.71	100.58	99.77	100.74

TABLE (*Continued*)

		NEW JERSEY DISTRICT					
		Rockingham clay	Plastic clay (No. 32)	No. 1 fine clay	Plastic clay (No. 38)	No. 2 fine clay	Plastic clay (No. 30)
Fusion point	Cone	27–28	30–31	Above 33	30	32–33	30
Firing properties							
Water of plasticity		37.1	30.3	38.7	19.1	37.0	37.3
Drying shrinkage		27.0	22.0	24.5	13.1	27.3	33.9
Av. firing shrinkage							
1200°C		30.6	13.6	33.4	.8	23.6	23.8
1240		34.0	15.4	36.2	1.2	26.0	27.9
1280		30.8	17.2	38.1	1.6	28.4	29.5
1320		21.6	18.7	40.8	2.5	31.4	28.8
1360		18.4	19.8	43.3	2.1	34.3	22.7
1400		15.4	21.5	44.9	1.6	35.6	16.1
1440		13.7	25.4	46.1	.4	38.5	7.7
1480		11.0	29.9	46.2	3.3	39.2	3.0
Av. porosity							
1200°C.		7.1	32.5	27.5	32.3	31.1	15.1
1240		.5	29.6	24.0	32.1	28.9	7.4
1280		.2	27.2	19.8	31.4	25.9	1.4
1320		9.5	26.3	13.5	30.8	22.0	3.2
1360		9.7	25.3	8.9	30.6	16.4	9.2
1400		15.1	22.5	2.6	30.6	12.2	14.4
1440		3.4	17.0	8.2	30.0	8.5	17.3
1480		17.7	6.6	7.7	26.6	6.1	23.3

CHEMICAL ANALYSES AND FIRING PROPERTIES OF FIRE CLAYS FROM VARIOUS PRODUCING DISTRICTS

		PENNSYLVANIA DISTRICT					SOUTHERN OHIO DISTRICT
Chemical analysis		Monument flint clay	Cambria County bond clay	Clinton County flint clay	Dean flint clay	Westmoreland Co. plastic clay	Plastic clay
Ignition loss		14.50	12.68	13.82			10.82
Silica		43.48	44.60	42.76	50.61	56.65	53.32
Alumina		39.20	37.35	39.03	45.33	36.33	29.47
Iron oxide		0.74	1.17	0.77	0.77	1.79	2.29
Titania		2.20	2.16	2.72	2.44	2.95	1.52
Lime		0.26	0.30	0.30	0.26	0.35	0.62
Magnesia		.31	.42	.37	.10	.66	.72
Alkalis		.08	1.57	.14	.24	1.23	.63
		100.77	100.25	99.91	99.75	99.96	99.39
Fusion point	Cone	32–33	32–33	32–33	33–34	30–31	28–29
Firing properties							
Water of plasticity		18.8	16.8	14.2	17.4	19.4	21.3
Drying shrinkage		11.3	10.3	2.9	9.1	19.5	18.0

Av. firing shrinkage						
1200°C	15.6	16.4	15.7	6.0	15.2	16.9
1240	17.9	17.6	16.9	6.2	18.3	18.6
1280	18.0	18.7	15.8	6.6	16.3	19.9
1320	19.1	19.1	14.3	7.4	15.0	19.8
1360	19.3	19.1	11.8	7.2	14.1	19.5
1400	18.4	18.9	13.0	7.1	13.0	19.0
1440	17.6	19.3	9.8	7.0	7.0	14.7
1480	17.4	20.9	10.4	6.7	2.3	7.0
Av. porosity						
1200C°	28.5	23.1	28.3	27.0	18.3	17.2
1240	27.7	22.3	27.3	26.8	12.0	13.6
1280	27.1	20.5	27.8	26.3	7.4	11.1
1320	25.0	20.3	28.1	26.0	4.3	9.5
1360	25.7	19.8	28.4	25.3	3.7	7.1
1400	25.6	19.1	27.6	24.2	2.6	3.6
1440	24.6	17.6	28.2	23.6	3.4	.2
1480	23.8	15.5	26.9	24.3	6.3	11.7

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SEGREGATION IN BINS[1]

By T. W. Garve

ABSTRACT

The formation of a cone in filling a bin causes ground materials to segregate. We have shown that bins will empty first through the center where the fine material is located and that the sides, where the coarser particles are, will follow through the center afterwards. This takes place regardless of the shape or the angle of the hopper bottom within practical limits. A retarder in center will somewhat correct segregation. To overcome segregation fully, the aforementioned cone formation must be avoided.

Segregation on Delivery into Bin

When grained materials such as ground grog and ground clay, even after screening, are delivered from a chute into a storage bin, a heap or cone always forms on top of the fill, which causes the material to segregate. The coarser and heavier particles, having the greater momentum, will roll down and collect at the bottom of the cone, and the finer and lighter particles will remain toward the center or top of the cone.

If the discharge end of the intake chute is located at or near the center of the bin, the coarser particles will be found along the wall of the bin and the finer particles around the center of the bin. If the discharge chute is placed alongside the inner wall of the bin we are getting only half of the cone, but still segregation.

In the manufacture of certain kinds of refractories, and also terra cotta, it is important that such segregation of grogs be avoided, in order to obtain a product uniform in mechanical strength and shrinkage.

The prevention of cone formation would seem the surest way of preventing segregation. One way of accomplishing this would be to devise a flexible spout, the discharge end of which would always have to be on top of the material and moving around continually, so as to keep the top of the bin practically level while the bin is being filled. It can readily be seen that such a device would be complicated.

Another way of preventing cone formation would be to use a continually rotating leveling device with prongs or scrapers to level down the beginning of a cone before segregation sets in. There might be possibilities along this line, although we do not know of any such device.

Segregation on Withdrawal from Bin

Now what is the result in emptying a bin? An interesting article was published in the *Tonindustrie Zeitung* of July, 1915, by Wittich, where it was demonstrated by photographs obtained from a bin model with a glass plate in front and subsequent layers of black and white sand behind, that

[1] Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, Feb., 1925. (Heavy Clay Products Division.)

the material above the bottom outlet would come through first, and that the sides would follow from the top down after the angle of slide is obtained. Figure 1 is a reproduction of one of those illustrations, the second in that series. The author was particularly interested to show that materials poured into the bin last did not come out last, as was generally supposed, but followed through the center instead.

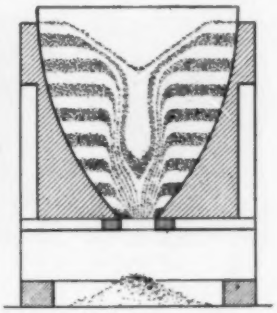

FIG. 1.

Influence of Angle at Bottom

We wish to call attention to the dished bin walls used in the experiment. The question is whether or not this same would be true for ordinary bins such as we are using, with a straight hopper bottom, and whether or not this angle of hopper bottom will influence in some degree the manner in which the bin is emptying—especially for larger angles.

It was claimed that the bottom should have an angle of 52° to get material from all over the bin. It was of vital importance for us to know this before large storage bins were constructed.

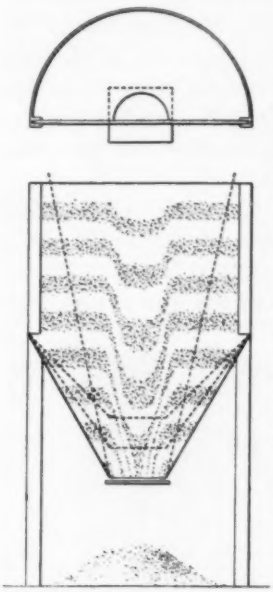

FIG. 2.

We constructed models of semi-circular cross-section, with a glass plate in front. We made hopper bottoms of 45°, 60°, and 52½°. In Fig. 2 we have a drawing of such a bin, the 60° bottom being heavily shaded and the other two hoppers shown in dots and dashes. The bottom slide has been opened a short time and closed again, as the different layers indicate.

In Figs. 3, 4 and 5 we have photos of the bins with the three different hoppers. In Fig. 5 the top layers have followed the downward trend simply because the bottom slide has been kept open a longer period of time. In Fig. 6 the slide was opened still more, until the top layer of white sand formed its natural angle of slide. All the layers resting upon the hopper are still in place, although the tendency later of the center path is to widen out gradually, the adjacent particles being pulled down by friction. The bottom opening is one-fourth of the width of the bin (corresponding to a two-foot feeder cylinder and an eight-foot diameter bin), and this is about all that is coming down at the

FIG. 3.

beginning, while the path will later increase to about one-third of the width of the bin.

A hopper bottom of 60° would be about the limit for a practical bin if storage capacity is not to be jeopardized. However, to make the ex-

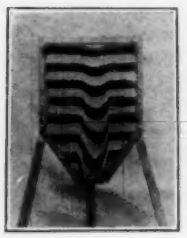

FIG. 4.

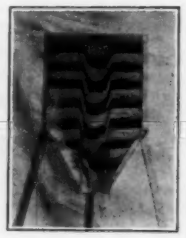

FIG. 5.

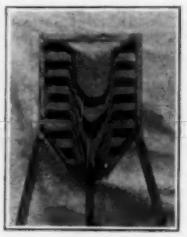

FIG. 6.

FIG. 7.

periment complete, we constructed a bin with side walls of 77° angle, shown in Fig. 7. At the beginning it emptied like the other bins through its center, but the sides soon began to slip out into the center path, and there was no angle of slide noticeable at any time on top of the fill. It would seem that in such a bin any tendency of the material to hang or bridge would be increased, due to the tendency of the sides to crowd in on the center. All the other hoppers carry the sides.

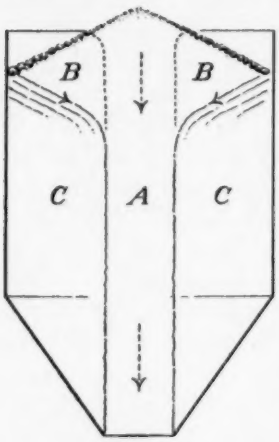

FIG. 8.

The experiment on the first three practical bins shows conclusively that the angle of the hopper bottom would not correct segregation. After the bin above the hopper is completely emptied the slope of the bottom should be steep enough so that the rest of the material will slide out. If this is not desired, a flat bottom is just as good as a cone.

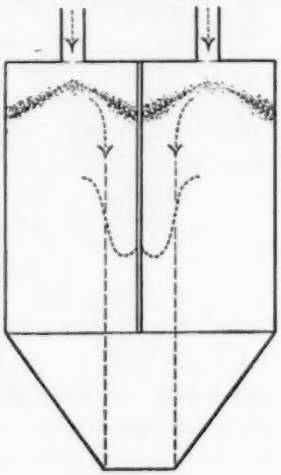

FIG. 9.

Figure 8 summarizes the information obtained. The contour on top of the fill shows the state of segregation as it is to be found all through the bin. The center, *A*, will come down first, then the remainder of the top cone, marked *B*, and finally the sides, *C*, will slide

from the top down. In other words, we are getting the finer material first and later the coarser material.

Use of Partitions It has been suggested to put partitions inside of the bin—in other words, to divide the bin up into smaller sections and to fill each section separately, but to draw from all sections at the same time. This is being done at the Lincoln plant of Gladding, McBean & Co. There is no question but that such bin construction will lessen segregation with reference to the filling of the bin. It had no effect on the method of emptying, as we have demonstrated by experiment.

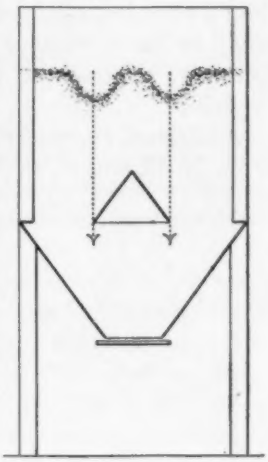

FIG. 10.

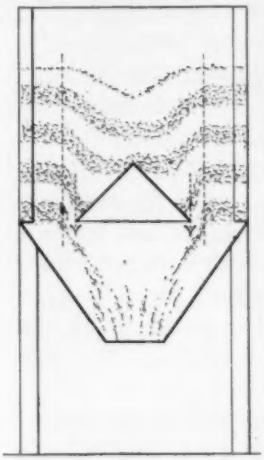

FIG. 11.

In Fig. 9 we have center partitions, one each way, but only one visible in the drawing. We are getting material from four cones, first the coarser particles, but later a mixture of fine and coarse material. Since in such smaller units the cones are lower, the segregation is also correspondingly less pronounced.

The thought suggests itself that a retarder in the center of the bin would help. We used two retarders, one measuring one-third the width of the bin crossways, shown in Fig. 10, and another one measuring one-half the width of the bin, shown in Fig. 11.

FIG. 12.

FIG. 13.

FIG. 14.

This retarding center cone in a round bin will cause the material to come down in a circular depression, taking the material from the center as well as from the sides—hence giving some mixture of fine and coarse material.

With the smaller retarder the apex of the depression was at the outer edge all the way through, as shown by arrows in Fig. 10. In Fig. 11, with the larger retarder, the apex started at the same place, but wedged out gradually as the downgoing material approached the outer edge of the wider retarder. The smaller retarder would be the better of the two, avoiding wedging.

Additional experiments with the smaller retarder are shown in photos, Figs. 12, 13, and 14, in three successive stages of emptying. The retarding cone had an inner flange against the glass plate hence the light outlines above the dark cone represent the actual size. The first material or center path *A* (marked again in Fig. 13) measures, according to the degree of emptiness, from $^1/_2$ to $^2/_3$ of the width of the bin against $^1/_3$ to $^1/_2$ without a retarder. Applying this to a bin of 8-feet diameter would mean that the remaining material on each side, to come out last, measures about 2 feet on each side with a retarder and 3 feet without such. Hence, with the retarder we are getting coarser material at the beginning during the down-path of the center, one foot more on the radius all around.

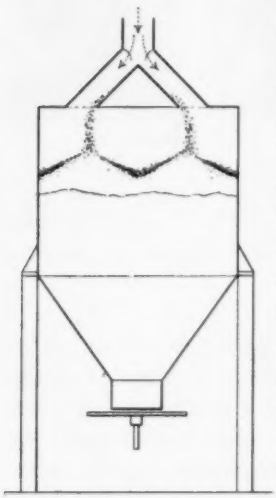

FIG. 15.

The character of the material in question will mainly determine the width of any such retarder. It can easily be placed in any bin. A screen analysis should be made to determine fully whether better results (and how much better) can be obtained. The cost of any such trial is negligible.

Apron to Prevent Segregation on Filling

In Fig. 15 we have one suggestion to better filling conditions by introducing a flaring apron above the bin to divert the material from the center to a ring half-way between the center and the bin wall. The same result is obtained with partitions, as shown in Fig. 9.

As outlined in the beginning, any real remedy must concern itself with avoiding cone formation in the filling of the bin. In one plant segregation was avoided by storing crushed grog, instead of ground grog, which introduces other problems.

GLADDING, MCBEAN & CO.
GLENDALE, CALIF.

THE QUANTITATIVE DETERMINATION OF IRON EXISTING AS FERROSILICON IN ARTIFICIAL CORUNDUM

By R. A. Heindl

ABSTRACT

A procedure is given for determining quantitatively the iron existing as ferrosilicon in artificial corundum.

Object

This research work was undertaken to find a rapid method for the determination of ferrosilicon in artificial corundum. Ferrosilicon has a deleterious effect when present in appreciable quantities in corundum used in the manufacture of fired products.

In the production of artificial corundum a careful analysis is made of all materials entering into its manufacture. The mix which enters the furnace is so proportioned as to produce ferrosilicon which is magnetic (approximately 80% iron), thus making it readily removable with magnets.

Material Used Artificial corundum of 10, 24, 30, 90 and 180-mesh size, which had received the manufacturer's full purification treatment, was used for this work.

Problems Undertaken Determinations of:

1. Total iron both as ferrosilicon and as iron oxide which is present in the grain.
2. Percentage of iron obtained by subjecting the grain to an acid treatment.
3. Percentage of ferrosilicon removed by combing the grain with a magnet.
4. Percentage of iron oxide.

(*a*) In original corundum;

(*b*) In corundum from which ferrosilicon had been removed by acid treatment.

5. Percentage of iron present as ferrosilicon.
6. Percentage of titanium oxide: (*a*) In original sample of corundum;

(*b*) In corundum having received the acid treatment for removal of ferrosilicon.

For purposes of description of the various determinations made the results as obtained from the analysis of 180-mesh corundum are given. A complete tabulation of all results obtained through analyses of the various size grains is given on a following page.

Problem 1. Total Iron

A 2-gram sample of corundum was placed in a 30-cc. platinum crucible and a mixture of 20 cc. of concentrated nitric acid and hydrofluoric acid (3:1) added. The crucible was placed on a hot plate and the liquid completely evaporated with care so as to avoid spattering.

To the contents of the crucible were added 15 grams of fused potassium sulphate and the whole heated over a gas flame until complete solution of the solids.

After cooling the mass was placed in a 300-cc. casserole with 200 cc. of distilled water and 20 cc. of concentrated sulphuric acid. As soon as the liquid had boiled sufficiently to clear, any remaining particles were filtered off, dried, fused and brought into solution as before.

The liquids were combined and treated with washed hydrogen sulphide gas for the reduction of the iron present. (Scott's Chemical Analysis.) The solution was brought to the boiling point during the passage of the gas and at the end of about 10 minutes boiling any platinum sulphide present was filtered off.

The filtrate was boiled in an Erlenmeyer flask until all traces of hydrogen sulphide gas had disappeared. The solution was then rapidly cooled and the iron determined by titration with potassium permanganate. Duplicate determinations gave checking results.

180-mesh corundum	
Per cent iron	0.219
Per cent iron oxide	0.313

The figure of 0.219% represents the total iron present whether in the form of iron oxide or ferrosilicon, and the figure 0.313% simply is the conversion of the iron content 0.219 to iron oxide. This figure is given as oxide to simplify calculations and comparisons further on.

It may be stated that the stannous chloride method (Blair's "Analysis of Iron Ores") for reduction of the iron salts, and also the Jones reductor method, in which 3 cc. of a 10% solution of copper sulphate is added (see Treadwell-Hall "Quantitative Analysis") to suppress the effect of the titanium oxide, were used, but it was impossible to obtain check results and the iron content in all cases was too high.

Problem 2. Iron Soluble in Acid

Ferrosilicon, though difficult of solution in most acids can readily be dissolved in a mixture of 3 parts by volume of concentrated nitric acid and 1 part of hydrofluoric acid.

A 2-gram sample of corundum was placed in a platinum dish and 20 cc. of this acid mix added. The dish and contents were placed on a hot plate and the acid carefully evaporated until about 1 cc. remained. To this was added 15 cc. of concentrated sulphuric acid and evaporation continued for about one hour after strong fuming of the sulphuric acid. The treatment was conducted in this manner to prevent the formation of any insoluble nitrates and to permit the complete removal of all nitric acid. It was found that traces of nitrates in solutions of iron destroy the effect of potas-

sium permanganate to quite an appreciable extent causing consequent high and erroneous results.

The dish and contents were then placed in a porcelain casserole and boiled with 150 cc. of distilled water.

After filtering off and thoroughly washing the corundum the filtrate was subjected to the hydrogen sulphide gas to reduce the iron salts present, boiled to expel excess gas, cooled and the percentage of iron determined with potassium permanganate.

The corundum remaining on the filter paper was carefully washed into the platinum dish, dried and subjected to a second acid treatment identically as described above, and any iron extracted determined with potassium permanganate. The results as obtained on 180-mesh corundum are:

1st acid treatment, 0.168% Fe
2nd acid treatment, 0.008% Fe

These figures show that one acid treatment for grain as fine as 180-mesh removes practically all iron which is present as ferrosilicon. There is a possibility that 0.008% actually represents iron oxide which is present and which is explained in another paragraph.

Referring to the table on page 681 it is readily seen that one acid treatment does not remove all the ferrosilicon in the coarser grains. The larger the grain the less removed. This is of course self-explanatory, since the smaller the grain the more surface is exposed to the action of the acid. By crushing the grain to pass a 150-mesh sieve, after one acid treatment, it was fine enough to permit complete solution of any ferrosilicon present.

Problem 3. Iron Removed by Magnet

Ten-gram portions of original corundum, ground to pass 150-mesh sieve, were accurately weighed and placed on glazed paper. A strongly magnetized horseshoe magnet, having the poles fitted with an envelop to permit the complete and rapid removal of the magnetic material, was passed back and forth through the ground corundum until no further particles of ferrosilicon appeared on the magnet. The resultant ferrosilicon was weighed, care being taken not to include any fine particles of corundum. The result obtained using 180-mesh corundum was 0.02% of magnetic ferrosilicon.

Since this figure represents only approximately 80% of iron in combination as ferrosilicon it is readily seen that this method of separating and determining percentage of iron present as ferrosilicon is of no value, since the actual amount present is several times greater as explained under Problem 5, when determined by chemical analysis.

A portion of the crushed grain from which the magnetic material had been removed with the aid of the magnet after being subjected to a fusion with potassium bisulphate showed the presence of magnetic ferrosilicon.

The removal of only a portion of the ferrosilicon is doubtless due to adhering particles of corundum. Such small particles clinging to or being a part of the finely divided ferrosilicon counteract the attractive force of the magnet.

There is also the possibility of the presence of the small percentage of nonmagnetic ferrosilicon which is not removed by this process.

Problem 4. (*a*) Total Fe_2O_3 and (*b*) Fe_2O_3 Not Removed by Acid

(*a*) A 2-gram sample of corundum, ground to pass 150-mesh sieve, was dissolved by fusing with 15 grams of potassium bisulphate. After cooling, the mass was placed in a 300-cc. casserole containing 20 cc. of sulphuric acid and 200 cc. of distilled water and boiled until clear. After filtering and washing of the paper the iron oxide was determined as before by use of the hydrogen sulphide gas and potassium permanganate. The result obtained for 180-mesh grain was 0.216% iron oxide or 0.149% iron.

(*b*) The determination of iron oxide in corundum from which the ferrosilicon had been removed by the acid treatment was made on samples used in Problem 2, *i. e.*, those having received the acid treatment. A 2-gram sample was fused with 15 grams of potassium bisulphate until complete solution. After cooling, dissolving with water and acid, and boiling, the iron oxide was determined in the same way as under (*a*) above. The result for 180-mesh grain was 0.071% iron oxide or 0.050% iron.

Problem 5. Iron as Ferrosilicon

As stated in Problem 1, the total iron present in the 180-mesh corundum analyzed, whether as ferric oxide or ferrosilicon, was 0.219%. Since the sum of the first and second acid treatments is 0.176% iron and the percentage of iron oxide as determined under Problem 4 is 0.149%, this would give a total of 0.325% iron as present in the grain either as ferrosilicon, iron oxide or both.

Since the combined determinations as shown in Problem 1, show the total iron, both as ferrosilicon and as ferric oxide, to be 0.219% it is evident that either the ferric oxide is attacked in the acid treatment or that the ferrosilicon is attacked in all steps.

When subjecting 10 mgs. of iron oxide to the acid treatment it was found that it readily dissolved. This proved that the iron oxide in the corundum was partially attacked, but not complete enough to permit it being taken into consideration in the calculations. As a matter of fact the grain, after having received 2 acid treatments, in the case of 180-mesh size, showed 0.071% ferric oxide when dissolved in a fusion of potassium bisulphate in comparison with 0.216% (Problem 4-*a*) given in the untreated grain.

Ten grams of finely divided ferrosilicon were subjected to a potassium

bisulphate fusion. It was found that even with this large amount of ferrosilicon as compared with the amount actually present in finished corundum grain the action of the fusion was very slight, not over $2^1/_2$ to 3 parts being dissolved out of 100. With the small amount of ferrosilicon actually present in finished corundum this slight action due to the potassium bisulphate fusion is negligible.

When we now review these figures we can definitely establish a value for the ferrosilicon which is present in 180-mesh corundum as follows:

	Per cent iron
Combined acid and fusion treatment	0.219
Fusion of original grain with potassium bisulphate	.149
Iron present as ferrosilicon	0.070

When the silicon-iron ratio of the ferrosilicon is known (in this case approximately 80% is iron) the percentage of ferrosilicon can be easily computed from this final value, which in this case is .070%.

In analyzing the grain for ferric oxide from which all magnetic ferrosilicon possible had been removed with a magnet, it was found that the result obtained was slightly lower than that shown above although within checking results. For all ordinary purposes it should not be necessary to remove the magnetic ferrosilicon before determining the ferric oxide.

Problem 6. Titanium Oxide

For the determination of titanium oxide[1] the solution obtained from the fusion of potassium bisulphate was brought up to 250 cc. in a quantitative flask. Twenty-five cc. of this solution was used for the determination of titanium oxide by placing it in a color tube and bringing it up to 100 cc. with water containing 5 cc. of a 10% solution of hydrogen peroxide which acts as oxidizing agent. The color was compared in the usual manner with a second color tube having a blank made up of water, 5 cc. of hydrogen peroxide and a few cubic centimeters of sulphuric acid. Standardized titanium oxide was added to the blank until the color compared favorably with the unknown. The following results were obtained in the analysis of 180-mesh corundum.

Titanium oxide in sample having received the acid treatment for removal of ferrosilicon—1.55%.

Titanium oxide in corundum having received no acid treatment—3.25%.

These determinations are given as further evidence that the acid treatment attacks other impurities in the corundum besides the ferrosilicon for which it is primarily intended and also gives an approximation of the extent to which the ferric oxide is removed. It is on account of the pres-

[1] This procedure is taken from Scott's "Standard Methods of Chemical Analysis."

ence of this titanium oxide that the selective reducing agent is used for determining compounds of iron.

Conclusions

From the foregoing it may be seen that the iron as ferrosilicon can be determined by the following steps:

1. Determine the total iron whether present as ferrosilicon or ferric oxide by the combined acid treatment and potassium bisulphate fusion.
2. Determine the amount of ferric oxide present by the fusion method with potassium bisulphate.
3. Subtract the iron oxide as determined in the second step from the iron determined in the first step, both figures being reduced to "iron" and the difference represents the percentage of iron present in the corundum as ferrosilicon.

The following table gives the percentages of the iron present as ferrosilicon in the grains on which experimental work was done:

Corundum	Per cent
10-mesh	0.171
24-mesh	.120
30-mesh	.120
90-mesh	.087
180-mesh	.070

The results from analyses of various sized grains follow.

Mesh	10 %	24 %	30 %	90 %	180 %
Total Fe either as FeSi or Fe_2O_3	0.320	0.269	0.269	0.236	0.219
Fe obtained first (*a*) acid treatment	.118	.118	.101	.151	.168
Fe obtained second acid treatment. (*a*) crushed to pass 150 mesh	.117	.101	.084	.050	.008
Fe_2O_3 on above sample after two acid treatments	.115	.071	.090	.06	.071
Fe_2O_3 original sample reduced to Fe	.149	.149	.149	.149	.149
Ferrosilicon removed by magnet	.12	.09	.02	.01	.02
Titanium oxide in original sample	3.30	2.80	2.90	2.85	3.05
Titanium oxide in sample having received acid treatment	1.66	1.65	1.45	1.65	1.55

CERAMIC ABSTRACTS

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Vol. 4 **October, 1925** **No. 10**

Author Index[1] to Ceramic Abstracts for October

AUTHOR	PAGE
Ando, K.	267
Aone, R.	270, 282
Auger, V.	292
Austin, A. O.	272
Baker, J. R.	274
Barratt, T. and Winter, R. M.	289
Bertrand	293
Bigelow, F. M. and Throm, A. J.	276
Bigot, A.	271
Bock, W. E.	275
de Boer, J. H.	280
Bronn, J.	278
Brown, C. M.	274
Brownlie, D.	294
Buberl, C.	281
Butcher, C. H.	295
Coe, I. J.	270
Corl, R. M.	274, 275, 276
Cramer, A. N.	277
De Wit, H.	285
Drake, W. C.	282
Escat-Serra, R.	288
Ewing, R. G.	273
Ferguson, W. C.	277
Ferngren, E. T.	274
Fujiwara, S.	286
Fujiyoshi, K.	267
Geiger, C. F.	281
Gosreau, R. C.	287
Grum-Grjimajlo, W.	278
Hall, F. W.	294
Hammer, J. M.	270
Hauser, E.	277
Hawke, C. E.	281
Heal, W. E.	276
Higgins, F. W.	283
Hirano, K. and Komori, S.	284
Horie, K.	277
Houldsworth, H. S. and Cobb, J. W.	288
Hugill, W. and Rees, W. J.	280
Hutin, A.	288
Inokuchi, S.	268
Ishikawa, J. and Hattori, R.	267
Johannsen, A. and Phemister, T. C.	291
Junius, G. E.	280
Kanashima, S.	267
Kato, S.	267
Kawase, I.	277
Keever, P.	266
Keppeler, G.	269
King, J. G. and Blackie, A.	292
Kondo, S.	290
Krausse, C. C.	295
Kumazawa, J.	291
Larson, J. A.	272
Lawson, H. B.	273
Lebedev, A. A.	271
Lewis, W. C. McC.	294
Litinsky, L.	278
Ludlow, E. R.	295
Martin, L. C.	268
Matsubara, A.	294
Matsumura, H.	282
Mauri, A.	270
Meehan, P. A.	285
Melhase, J.	287
Mellor, J. W. and Scott, A.	288
Meurer, N.	285
Miller, L. B.	275, 276
Miller, W. A.	282
Mizobuchi, K.	268
Monk, R. H. and Whittemore, C.	287
Mulligan, M. J.	271
Nagata, T.	277
The Nippon Hard Faience Co.	283
The Nippon Toki Co.	266, 267
Ostwald, W. and Rath, W.	292
Owens, M. J.	273
Peiler, K. E.	272, 273
Phemister, T. C.	280
Rebuffat, O.	288
Roebuck, J. R.	292
Rothmund, V.	291
Roush, G. A. and Miyake, M.	293
Ruff	288
Russell, W. M.	281
Samoiloff, J. V.	289
Sano, T. and Shimizu, T.	283
Scarpa, O.	292
Schofield, F. H.	289
Seitosho, N.	267
Shearer, G.	288

[1] The abbreviation (*C. A.*) at the end of an abstract indicates that the abstract was secured from *Chemical Abstract* by coöperative agreement.

Author Index to Ceramic Abstracts for October (*Continued*)

Author	Page
Shioda, K. and Kajiwara, S.	268
Shofu, K.	270
Shoji, I.	266
Shoji, K.	268
Showers, L.	282
Shuman, C. and Worrall, A. G.	275
Sissingh, R.	272
Slingluff, H. G.	274, 275
Smalley, E. L.	285
Soubier, L. D.	276
Stearns, E.	284
Stenhouse, T.	272
Stott, V. H., Irvine, E. and Turner, D.	272
Sugiyama, M.	286
Sweet, J. A.	274
Tadokoro, Y.	279
Teague, M. C.	266
Thompson, W.	283
Toda, T.	283
The Tokio Electric Co.	277
The Tokio Hoonzai Co.	282
The Toyo Toki Co.	286
Uchida, T.	284
Van Buhler, J. J.	295
Van Dusen, M. S.	284
Veimarn, P. P. v.	293
Vogel, F. P.	284
Vondráček, R.	293
Wakabayashi, J.	267
Weber, E.	278
Weber, R.	279
Wilhelm, D.	266
Wormser, F. E.	286
Wyckoff, R. W. G.	292
Yoshioka, T.	267

Abrasives

Creation and development of the art of grinding. DONALD WILHELM. *The Glassworker*, **44** [43], 15(1925).—A history of the Norton Co. F. G. J.

PATENTS

Abrasive form, its composition and method of making the same. PAUL KEEVER. U. S. 1,548,145, Aug. 4, 1925. A compn. of matter for making abrasive forms adapted to be set permanently by baking and to be subjected to baking heat immediately on being formed, comprising an abrasive, glass, clay, a dry sodium silicate and a temporary binder.

Abrasive form and process of making the same. PAUL KEEVER. U. S. 1,548,146, Aug. 4, 1925. A compn. of matter for making abrasive forms adapted to be set permanently by baking and to be subjected to baking heat immediately on being formed, comprising abrasive grains, feldspar and clay, and a temporary binder, containing sufficient water to make the mass moldable, but only such an amt. of water that the mass is capable of absorbing moisture from a wet hand.

Process of treating latex and article therefrom. MERWYN C. TEAGUE. U. S. 1,550,466, Aug. 18, 1925. The process of treating latex which comprises thickening and stabilizing the latex by adding thereto an easily decomposable colloidal silicate in the presence of an alkali.

Art

PATENTS

Liquid gold containing a nickel salt. ICHITARO SHOJI. Japan. 1,937, Oct. 22, 1924.[1] Nickel resinate is used as a constituent of liquid gold. S. K.

Process of decorating pottery with liquid luster. NIPPON TOKI CO. Japan. 61,198, Sept. 15, 1924. To retard the drying of liquid luster for over-glaze decoration of pottery, clove or any other suitable oil is added to it. Two or more liquid lusters of different colors are made to flow in stripes on the surface of a pottery. Neighboring stripes will touch each other at points where the 2 liquids will be mingled soon. Then before the surface is completely dried, alcohol, ether or any other volatile liquid is made to fall in drops or painted on it. Surface tension of the liquid will produce spots. Then it is fired in a muffle kiln. The flow-painting is repeated and the spotted portions are painted with a liquid luster. The pottery is fired again in a muffle kiln. S. K.

[1] NOTICE: The revised patent law of the Japanese government took effect from Jan. 11, 1922 and new patent numbers began in 1924; therefore there are two series of the number in that year.

Process of decorating pottery with gold. NIPPON TOKI CO. Japan. 61,199, Sept. 15, 1924. A pottery is first decorated by transferring any design on its varnished surface with pigments other than gold on it. It is fired at 800–850°C. It is then painted with 3–5% gelatine soln., decorated by means of a gold transfer of special design and fired again at 600–850°C. S. K.

Process of manufacturing liquid gold. KUMATARO FUJIYOSHI. Japan. 2,602, Dec. 12, 1924. Gold, bismuth and cadmium are dissolved in aqua regia. The soln. is evaporated to dryness. Sulphureted balsam, resin, lavender oil, rosemary oil and nitrobenzene are added to the residue. S. K.

Black pigment for pottery. SHUICHIRO KATO. Japan. 2,913, Jan. 17, 1925. Small amts. of quartz and cobalt oxide are added to ferro-vanadium. The color is stable in fire and produces a nice bright black. S. K.

Filling material for potteries. KAZUO ANDO. Japan. 62,178, Jan. 28, 1925. A mixt. of 3 pts. of graphite and 4 pts. of lead-powder is heated up to 340–400°C and stirred well with addition of 3 pts. of sulphur. The fused mass is left to cool. To fill a hole in a pottery, that portion is heated by oxy-hydrogen flame until the glaze begins to melt. Then a small amt. of the material is put on the portion. It will melt soon and fill the hole. S. K.

Method of producing crystalline designs on biscuits. NAGOYA SEITOSHO. Japan. 62,162, Jan. 27, 1925. Pottery body is granulated by stirring its powder with water. The granules are covered with powdered pigments and pressed in a mold. The surface of the pressed ware is partly or wholly shaved with a knife or spatula and it is pressed again. Then it is fired. The ware may be fired without shaving, and polished afterward. S. K.

Under-glaze decoration of potteries by means of pasted pattern-paper. JIMPEI WAKABAYASHI. Japan. 3,898, March 25, 1925. Thin papers with patterns of rice-starch or gum arabic are stuck on the surface of a soft biscuit. It is then moistened with water and painted with pigments. The pigments permeate the paper and decorate the pottery. S. K.

Process of producing luster on glazed potteries. SHIGETA KANASHIMA. Japan. 62,280, Feb. 5, 1925. Buttons, beads or other glazed wares are fired in a kiln and drawn out while they are still 500–600°C hot; or the wares may be reheated after firing. The hot wares are then put into powder of volatile metallic compd., such as arsenious acid, chloride or nitrate of bismuth, tin, iron, copper, strontium, uranium, cobalt, chromium, gold, silver or platinum. S. K.

Process of producing luster on biscuit, glass or enameled ware. SHIGETA KANASHIMA. Japan. 4,430 (Supplement to Pat. 62,280), April 22, 1925. Hot biscuit, glass or enameled ware is brought into contact with arsenious acid, chloride or nitrate of bismuth, tin, iron, copper, strontium, barium, uranium, cobalt, chromium, gold, silver or platinum to produce a luster on its surface. S. K.

Method of manufacturing liquid gold. JIRO ISHIKAWA and REIZO HATTORI. Japan. 4,191 (Supplement to Pat. 35,932), April 10, 1925. Sulphureted balsam is added to a soln. of gold chloride and the mixt. is heated on a water bath. Gold resin sulphide, thus prepd., is washed and dried. Then resinates of rhodium and bismuth or those of rhodium, bismuth, aluminium and chromium are added. The product is dissolved in a mixt. of refined oils. S. K.

Process of manufacturing liquid gold. TOSAKU YOSHIOKA. Japan. 4,425, April 22, 1925. Gold balsam sulphide, obtained by treating a soln. of gold chloride with sulphureted balsam, is washed, dried and made into a viscous soln. with a solvent. Liquid gold is prepd. by adding cobalt resinate to it. S. K.

BOOK

Colour and Methods of Colour Reproduction. L. C. MARTIN. With chapters on Colour Printing and Colour Photography by W. GAMBLE. London: Blackie & Son, Ltd. 187 pp. 12s. 6d. Reviewed in *Chemistry and Industry*, **44**, 489(1925).
(*C. A.*)

Cement, Lime and Plaster

On the method of determining final set. K. SHIODA AND S. KAJIWARA (Comm. of Cement Specif.). Jap. Assoc. of the Port. Cement Engineers, *Report* **16** [1], 18 pp. (1924).—According to the Jap. Port. Cement Specif., the final setting is said to have finished when the Vicat needle cannot penetrate the mass at all. The Comm. recognizes the grave objections to the method and recommends, after long invest., to consider the final setting finished the moment the needle sinks about 0.25 mm. into the mass.
S. K.

On the revision of the method of determining setting time in the Cement Specifications. K. SHIODA AND S. KAJIWARA (Comm. of Cement Specif.). Jap. Assoc. of the Port. Cement Engineers, *Report* **16** [4], 82 pp.(1924).—Results of the elaborate invest. on the influence of temp. on the setting time are described. In conclusion, the Comm. proposes to specify the temp. in the detn. of the setting time as 15–25°C. The present specif. has no description on it.
S. K.

On the determination of magnesia in Portland cement. KATSURO MIZOBUCHI (The Onoda Cement Mfg. Co.). Jap. Assoc. of the Port. Cement Engineers, Supp. to *Report* **16** [1], 16(1923).—*A. Care to be taken in the detn. of silica and lime.* (1) The silica residue must not be heated over 110°C. (2) Excess of ammonia has to be avoided in the pptn. of calcium. The ppt. must be filtered in 4–5 hrs. after pptn. and be washed with water contg. ammonium oxalate. *B. Treatment of the filtrate from lime detn.* Slightly acidify the filtrate and evap. it to about 100 cc. Add about 30 cc. of satd. soln. of ammonium chloride (15°C), neutralize with ammonia and add about 10 cc. of ammonia (sp. gr. = 0.892). *C. Pptn., filtration and washing.* Add about 5 cc. excess of satd. Na_2HPO_4 soln., then 40–50 cc. of 10% ammonia. Stand in cold place for a night and filter. Wash the ppt. with 2.5% ammonia. *D. Ignition.* Do not use nitric acid in igniting the ppt. of magnesium.
S. K.

On the relation between fineness and strength of Portland cement. SHIGETSUGU INOKUCHI (The Asano Cement Co.). Jap. Assoc. of Port. Cement Engineers, Supp. to *Report* **14**, 17–25(1923).—Tensile strength of neat Port. cement briquettes increases with its fineness until a certain limit is obtained, beyond which it begins to decrease. Such a limit is shown with a Japanese clinker when it is ground to leave 6% residue on 4900-mesh per sq. cm. Tensile and crushing strengths of 1:3 mortar briquettes increase with fineness of the cement.
S. K.

On the addition of volcanic ash to Portland cement. KI SHOJI. *Jour. Jap. Ceram. Assoc.*, **33** [386], 41–56(1925).—*I. Introduction.* The effect of volcanic ash in Port. cement mortar for marine constructions owes probably to the formation of the hydrated lime compds. from sol. silicic acid in volcanic ash and calcium hydroxide from the cement and also to the action of the hydrated lime compds. which fill the pores in the constructions and make them waterproof. *II. Kind and proportion of volcanic ash.* The effect of mixing 0–200% of 5 different volcanic ashes to slow setting Port. cements on their setting time is reported. The results may be classified as follows: (1) Retardation of only final set, (2) excessive acceleration of initial set as well as retardation of final set and (3) excessive acceleration of both initial and final sets. Of 5 volcanic ashes, only *A* belonged to (3); *e. g.*, its 20% changed the initial and final sets of a cement, 5.23 and 9.33, to 0.04 and 1.37 (hr.-min.) resp. *III. On the volcanic ash. A.* Anal. of the 5 volcanic ashes are as follows:

	Moist.	Ig. loss	Treated with NaOH and HCl solns. Soln. SiO_2	Soln. Al_2O_3	Soln. Fe_2O_3	Soln. CaO	Soln. MgO	Alkalis
A	4.45	14.81	33.26	28.03	8.30	0.57	1.03	1.92
B	1.62	6.19	38.16	14.56	2.31	1.14	0.63	5.64
C	3.63	10.10	45.21	11.75	1.91	1.32	0.77	4.81
D	0.80	1.83	22.92	7.20	1.64	2.72	0.44	3.95
E	2.43	6.29	30.20	11.27	4.67	2.44	1.15	5.68

The abnormal acceleration of *A* is probably due to its high content of sol. alumina. The author treated *A* and *B* with a soln. of caustic soda, acidified the solns. with HCl and finally obtained ppts. of silicic acid and alumina with ammonia, whose anal. are as follows:

	Ig. loss	Silica	Alumina
Ppt. from *A*	27.82	35.04	34.84
Ppt. from *B*	25.94	45.70	26.62

The action of these ppts. on a cement was as follows: (Temp. of room = 20.5° C).

	Port. cement	Port. cement + 4 %	Port. cement + 4% ppt. from *A*	Port. cement + 4% ppt. from *B*
Water (%)	25.0	32.2	25.5	25.5
Initial set (hr.-min.)	3.13	0.03	0.03	0.38
Final set (hr.-min.)	5.23	0.08	0.22	3.13

IV. Influence of SO_3 in cement on the action of volcanic ash. The author studied the action of *A* on typical Jap. Port. cements with the result that the av. content of SO_3 in nine cements whose setting were accelerated by *A* is 1.16%, while that in nine cements which remained slow setting is 1.35%. He also found that the former kind of the cement can surely be changed to the latter by adding gypsum so as to make its content in SO_3 about 1.6%. S. K.

Scientific basis of lime-burning practice. G. KEPPELER. *Z. angew. Chem.*, **38,** 397–405(1925).—Theoretical considerations in *lime burning* are discussed. The yield of CaO should be 56% of the $CaCO_3$ used. If instead of 56%, the yield is *A*%, the quantity of unburned lime is $(A - 56)100/44 = 2.28\ (A - 56)$, and the quantity of completely decomposed lime is $100 - \{[2.28(A - 56)100]/A\}$. Since the sp. gr. of CaO = 3.08, and of $CaCO_3$ = 2.72, the CaO should occupy only about 50% of the original vol. of the limestone, but it is very porous and the shrinkage in vol. amts. to only 10–12%. CaO really exists in 2 forms: amorphous, with sp. gr. 3.08, and cubically cryst. with sp. gr. 3.40 and refractive index 1.83. The first is stable at lower temps., changing into the second at 400–430°. A diagram is given by which all other constituents can be detd. from the CO_2 content. This is assuming no excess of air and theoretical yields, whereas in practice the CO_2 content of the gas is usually between 15% and 35%, with a gas vol. of 3–10 cu. m. per kg. of limestone burned at 900°. The decompn. tension of $CaCO_3$ is plotted against temp. The temp. of the reaction can be considerably lowered by the addition of reducing materials such as coal or org. matter. They disturb the equil. by reducing the CO_2 to CO. H_2O vapor accelerates the reaction. The nature of the limestone used is important, particularly if other carbonates are present which have a lower decompn. pressure than $CaCO_3$. Formerly the furnace lining was always basic in nature, but there is now a tendency to use acid lining. However, the acid material shows greater vol. change with change in temp. and is therefore more brittle. (*C. A.*)

PATENTS

Manufacture of white hydraulic cement. IRA JUDSON COE. U. S. 1,547,365,

July 28, 1925. A white hydraulic cement consisting of the sinter and ground mix of an iron-free limestone and an iron-free labradorite.

Method of fire-proofing safes. RIUKICHI AONE. Japan. 61,443, Oct .22, 1924. A mixt. of 50–60 pts. Kokaseki (a pumice produced in the Shizuoka Prefecture), 10–20 pts. asbestos and 10–20 pts. slag cement is kneaded with water, brine or soln. of other salt. Plates made of the plastic body are used for fire-proofing safes. S. K.

Manufacture of lime-sand concrete and bricks, pipes, and the like. ANON. Brit. 222,923. *Quarry and Surv. and Contractors' Jour.*, **30**, 205(1925). The invention consists in mfg. lime-sand mixts. by adding a predetd. amt. of sulphuric acid to the sand-lime mixt. The process may further be improved by adding coal or other tar to render the product anhydrous so that it will absorb a minimum quantity of water and effect a better and quicker hardening and more effective internal adhesion. O. P. R. O.

Enamels

PATENT

Process of rust-proofing pins for porcelain teeth. KAJO SHOFU. Japan. 2,600, Dec. 12, 1924. In the process of fixing a pin, which is made of nickel or an alloy and may be gilded or not, to a porcelain tooth, the exposed portion of the pin is coated with a fusible compd. The coating is melted later in firing. S. K.

Glass

Additional epochs in manufacture of Glass. ANON. *Nat. Glass Budget*, **41** [14], 9 (1925).—Reprints an article of twenty years ago on epochs of glass making and describes the advances since then. F. G. J.

Old Sandwich glass factory's centenary. ANON. *Pottery Glass & Brass Salesman*, **31** [23], 13(1925); *The Glass Worker*, **44** [40], 13(1925).—An account copied from the Boston Herald by B. Burgess of the methods and manners of life of the glass workers there in the 80's when she visited it as a child. The factory has been closed since 1888. F. G. J.

Thorough and practical training in common sense and fundamentals to be aim of glass laboratory. J. M. HAMMER. *The Glass Worker*, **44** [44], 15(1925).—An interview with A. Silverman on the plans and aims of the Lab. of Glass Tech. at the Univ. of Pittsburgh. It will be a part of the Dept. of Chemistry in the new "Cathedral of Learning." The aim will be to prepare men who can be of the highest service to the glass indus. With a knowledge of chemistry will be combined practical training in glass factories. F. G. J.

Chemical and thermal resistance of laboratory glasses. ARNALDO MAURI. *Atti congresso naz. chim. ind.*, **1924**, 330–40; cf. *C. A.*, **18**, 2063.—Tests were carried out on 7 important glasses, *viz.*, old green label Jena (**I**), 1920 Jena (**II**), 1922 Italian Murano (**III**), 1923 Murano (**IV**), original Pyrex (**V**), French Labo (**VI**) and Belgian Boromica (**VII**) to det. their resistance to reagents and to sudden chilling. A comparison of the quant. results with their compn. shows best the effect of various constituents. In the 1st series the glass was heated in an autoclave at 120° for 3 hrs. The following data give the loss in mg. with 300 cc. of soln. in 500-cc. flasks for the 7 glasses: H_2O 0.5, 0.4, 0.6, 0.5, 0.4, 0.7, 0.6; 0.1 *N* HCl 2.6, 2.1, 2.5, 2.2, 2.0, 2.5, 2.3; 0.1 *N* NH_4OH 9.6, 9.5, 9.5, 9.8, 9.7, 10.0, 11.2; 0.1 *N* NH_4Cl 3.4, 2.0, 3.6, 2.0, 1.8, 2.1, 3.6; 0.1 *N* $(NH_4)_2CO_3$ 3.7, 4.0, 3.5, 3.5, 4.2, 4.1, 4.3; 0.1 *N* NaOH 81.1, 123.0, 80.5, 107.8, 229.0, 84.3, 82.0; 0.1 *N* Na_3PO_4 12.0, 9.0, 10.5, 11.5, 13.5, 10.8, 10.7; 0.1 *N* Na_2CO_3 45.6, 72.0, 44.0, 68.0, 101.3, 47.2, 46.0; 0.1 *N* Na_2S 90.0, 75.2, 89.9, 84.0, 75.5, 94.1, 93.0. In further tests the solns. were boiled for 2 hrs. in the open. The losses were: *N* HCl 3.3, 2.0, 3.1, 2.5, 2.0, 3.1, 3.0; 0.1 *N* HCl —, 1.0, 3.5, 2.0, 0.9, —, —; 0.1 *N* HNO_3 —, 0.8, 1.2, 0.9, 0.7, —,

—; 0.1 *N* H_2SO_4 —, 1.0, 1.1, 1.2, 0.5, —, —; 0.1 *N* $(CO_2H)_2$, 0.1 *N* H_2S, satd. aq. SO_2 and 0.1 *N* NH_4OH —, 0, 0, 0, 0, —, —; *N* NH_4OH —, 4.3, 4.2, 2.5, 2.8, —, —; *N* NH_4-Cl 0.3, 0.2, 0.5, 0.2, 0.1, 0.4, 0.5; *N* $(NH_4)_2CO_3$ —, 1.5, 1.0, 1.0, 2.0, —, —; 0.01 *N* NaOH 10.0, 13.0, 9.0, 10.7, 19.5, 10.5, 10.0; 0.1 *N* Na_3PO_4 —, 1.5, 3.0, 2.3, 2.0, —, —; 0.1 *N* Na_2CO_3 14.8, 17.6, 14.5, 17.5, 24.0, 16.3, 15.0; 0.1 *N* Na_2S 9.5, 6.1, 6.0, 6.5, 7.4, 13.3, 12.5; 0.1 *N* $(NH_4)_2S$ 2.6, 1.6, 1.8, 2.5, 2.2, —, —. In expressing resistance to reagents, the customary units involving loss per vol. should be replaced by the more rational *loss per unit area of surface exposed*. Since evapn. and ebullition cause a continual variation in this surface area, accurate resistance tests should always be done in an autoclave. It would be of great advantage if data were available for every type of glass to give *correction coeffs.* which would represent the losses in various reagents at different concns. and temps. for a given time. In illustration of this the following data give the corrections to be applied to the 7 glasses in quant. analysis, based on a 500-cc. flask with 300 cc. of soln. boiled over a flame for 30 min.: H_2O all 0; *N* HCl 1.0, 0.5, 0.5, 0.4, 0.3, 1.0, 0.9; *N* NH_4OH 1.0, 1.4, 1.0, 1.3, 1.5, 1.6, 1.5; 0.01 *N* NaOH 3.0, 4.5, 2.5, 4.3, 6.0, 4.2, 4.0; 0.1 *N* NH_4Cl —, —, 0.1, —, —, —, —; 0.1 *N* Na_3PO_4 0.1, —, 0.1, —, —, 0.2, 0.1; 0.1 *N* $(NH_4)_2CO_3$ —, 0.1, —, —, 0.1, —, —; 0.01 *N* Na_2CO_3 1.1, 1.2, 1.1, 1.3, 1.6, 1.4, 1.2; 0.01 *N* Na_2S 1.3, 1.1, 2.0, 1.2, 1.1, 2.7, 2.5. On repeating the same treatment the losses decrease progressively, so the data are comparative only. On chilling from 150° to 15°, **V** and **IV** gave excellent results, **III, I, II** and **VII** were less resistant but were good and **VI** was poor. The analyses showed the samples to contain in %: SiO_2 64.5, 75.5, 66.0, 78.0, 81.0, 67.5, 64.0; B_2O_3 10.8, 8.65, 10.0, 10.0, 12.0, 5.0, 13.0; Al_2O_3 4.4, 4.7, 6.4, 4.8, 2.5, 0.6, 5.5; ZnO 11.1, —, 10.1, —, —, 6.0, 10.1; CaO 0.6, 0.9, 1.1, 2.4, 0.0, 5.7, trace; Fe_2O_3 0.2, 0.35, 0.3, 0.2, 0.2, 0.3, 0.35; BaO 0.0, 4.5, 0.0, 0.0, 0.0, 0.0. 0.0; Na_2O 7.5, 4.8, 6.0, 4.2, 4.5, 6.5, 7.1; K_2O 0.4, 0.6, 0.0, 0.0, 0.0, 4.9, 0.0. (*C. A.*)

The crystallization of glasses. Paving with crystallized basic glasses. A. BIGOT. *Rev. universelle mines*, **5** [7], 246–57(1925).—A general description of the physics and chemistry of glass, with analyses of 8 types. An illustrated description is also included of the *sources and properties of basic glasses* (cf. *C. A.*, **17**, 2769) *from slags, scoria*, etc. which have become of use as flagstone and paving materials. (*C. A.*)

Polymorphism and tempering of glass. Preliminary communication. A. A. LEBEDEV. *J. Russ. Phys. Chem. Soc., physical sect.*, **50**, 57(1921).—There is a sudden change of properties of glass at temps. 540–600°, as proven in the study of heating curves and changes of double refraction and coeff. of expansion with the temp. This change is attributed to a polymorphous transformation closely allied to the transformation $\alpha \rightleftharpoons \beta$ quartz. Glasses are assumed to be an aggregation of highly dispersed crystals among which quartz crystals also are present, probably in the form of solid solns., as a result of which the transformation takes place over a certain temp. interval, the glass passing through a no. of equil. states. This explains the difference in glasses tempered at different temps. and which cannot be explained by internal strains alone. Internal strains are some of the results of polymorphous transformations which are accompanied by vol. changes. Changes of the coeffs. of refraction and expansion have been studied by new methods which have been described in detail. (*C. A.*)

The conductivity of annealed and unannealed soda-lime glasses. M. J. MULLIGAN. *Trans. Roy. Soc. Canada*, **18** [III], 120–1(1924).—The conductivities of annealed and unannealed soda-lime glass exhibit a marked difference (approx. 200%). The conductivities are the same kind of function of the temp. in both cases, so that the change in glass brought about by annealing is one of degree rather than of kind. Detns. were made of the wts. of materials that were electrolyzed into these glasses at 180° from a molten anode (KNO_3 and $AgNO_3$). The amts. were approx. inversely proportional to the resistance of the glasses, but the depth of penetration of Ag ions does not bear

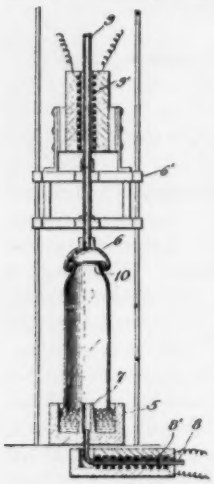
out the assumption that there is a marked difference in the degree of ionization of the 2 glasses. The major factor in increasing resistance by annealing is a decrease in the mobilities of the ions. (*C. A.*)

Surface layers on glass. R. SISSINGH. *Physica*, **5**, 77–83(1925); cf. *Arch. Néerl.* **8** [IIIA], 142(1924).—Light rays reflected by an old glass prism showed considerable elliptical polarization due to a surface layer of appreciable thickness (*d*). By a modification of the older theories of Cauchy and of van Ryn van Alkemade it is possible to calc. *d*. In the sample mentioned, 3.0×10^{-5} mm. was found, after grinding 1.0×10^{-4} mm. The first layer probably consisted of water, the last of air. (*C. A.*)

Mechanical strength of porcelain insulators. A. O. AUSTIN. *Elec. World*, **85**, 1253–5(1925).—A well designed insulator is a compromise between working load, ultimate test strength and thermal stress. A. discusses at length the various problems connected with the manuf. of the modern insulator. (*C. A.*)

Viscosity measurements with glass. V. H. STOTT, EDITH IRVINE AND D. TURNER. *Proc. Roy. Soc.* (London), **108A**, 154–71(1925).—Two app. are described for viscosity measurements of (1) $10^{16.6}$ to 10^{6} poises and (2) from 10^{4} to 10^{2} and less. In the former, the higher viscosities (10^{17} to 10^{9}) are calcd. from the angular velocity of a glass rod which twists under a known torque and the lower viscosities (10^{9} to 10^{6}) from the angular velocity of a rod of "reactol" plunged in the glass. In the latter, the rate of fall through the glass of a partially counterpoised Pt-Ir ball suspended from a wire of the same material was used to det. the viscosity. A *furnace* which will give a temp. const. to 2° or 3° for an hour or two is described. Curves showing the temp.-viscosity relations for 13 (analyzed) glasses are given. (*C. A.*)

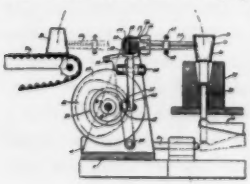
PATENTS



Method of drawing glass cylinders. THOMAS STENHOUSE. U. S. 1,546,949, July 21, 1925. The method of drawing hollow glass articles, which consists in drawing a hollow article from a bath of molten glass, introducing a preheated fluid into the opposite ends of the hollow article, and increasing the volume of such fluid admitted to each end of the article in proportion to the progressively increasing length of the article.

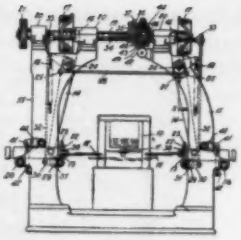
Glass float. JOHN A. LARSON. U. S. 1,547,052, July 21, 1925. As an article of manuf. a float comprising a hollow glass body and a nipple on the body adapted to connect with a float arm, said nipple having a non-circular flange at the inner end thereof embedded in the glass and held by the glass against displacement.

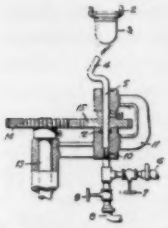
Taking-out device for glass-shaping machines. KARL E. PEILER. U. S. 1,547,146, July 21, 1925. The combination with a glass-shaping mach. embodying a mold having a body portion and a movable bottom valve, of means for actuating said valve to elevate the ware from the body portion of the mold, a take-out device coöperating with said bottom valve, including a ware-receiving holder provided with a member overlapping an end portion of the ware adapted to retain the ware in said holder, and means for actuating said holder to transfer the ware from said valve to a receiving station.



Apparatus for separating molten glass into mold charges. KARL E. PEILER. U. S. 1,547,147, July 21, 1925. In app.

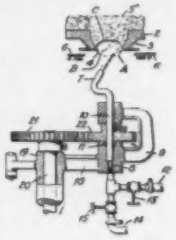
for separating molten glass into mold charges, the combination of shears to sever the glass, means for changing the plane of the shears during each severing operation, and means for adjusting the severing speed of the shears.



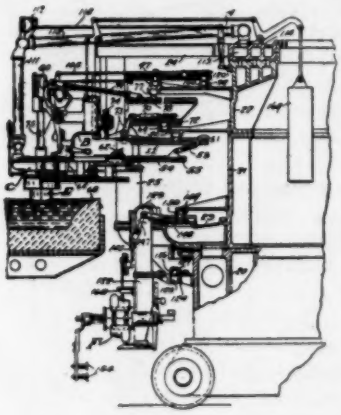


Method and apparatus for reheating glass parisons. KARL E. PEILER. U. S. 1,547,148, July 21, 1925. A glass-working burner comprising a flame-discharging nozzle, and means for revolving said nozzle.

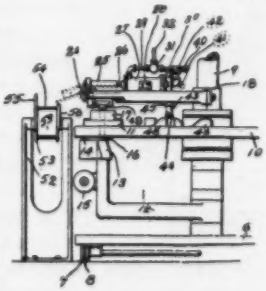
Feeding molten glass. KARL E. PEILER. U. S. 1,547,149, July 21, 1925. App. for feeding molten glass, comprising a container for the glass having a discharge outlet, and means for directing a revolving flame toward the said outlet.



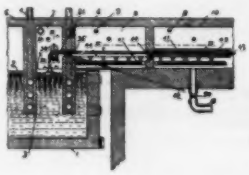
Glass-forming machine. MICHAEL J. OWENS. U. S. 1,547,439, July 28, 1925. In a glass gathering mach. the combination of a mold carriage, means to rotate it continuously about a vertical axis, a sectional mold frame carried thereby, blank mold sections carried by said frame sections, means to move the frame sections rectilinearly toward and from each other in a direction radial to the mold carriage and thereby move the mold sections to and from each other, said sections being provided with a series of mold cavities at substantially equal distance from the center of the mach., neck molds adapted to register with the blank molds, means to charge the molds, said neck molds being operative to support the bare blanks when the blank molds are opened, finishing molds to enclose the blanks, and means to blow the blank in the finishing molds.



Lid take-off for glass-forming machines. HARRY B. LAWSON. U. S. 1,547,503, July 28, 1925. A lid take-off for glass-forming machs. comprising in combination with a glass-forming mach. having a rotary table provided with a plurality of molds, the means for lifting the finished article of said molds, of a plate pivotally mounted above the path of travel of said molds, a pocket formed on the underneath surface of said plate for receiving the finished article when raised out of the mold, and means for turning said plate with the finished article as lodged in the pocket and discharging the same on to a conveyor.



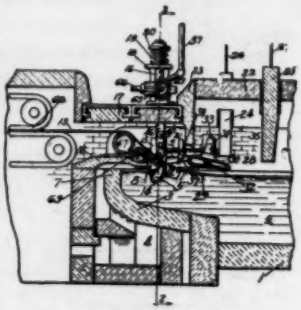
Drawing sheet glass. ROBERT G. EWING. U. S. 1,547,797, July 28, 1925. In continuous sheet glass drawing mechanism, a tank for molten glass supply, a bending member for glass from the tank, a leer, a perforate diaphragm in the leer, supporting means for the glass in the leer, on one side of which the formed glass may pass, and a burner on the opposite side of the diaphragm from the glass. In sheet glass drawing mechanism, a tank for molten glass supply,

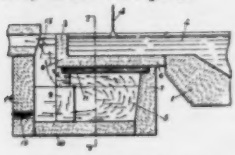


and a transversely extending member disposed above the tank in proximity thereto forming a convex bending guide for glass from the tank, there being fluid carbon compound supply means at the glass bending region of the member for lubricating the member.

Cased glass and articles made therefrom. JAMES REID BAKER. U. S. 1,547,715, July 28, 1925. Composite glass comprising a coating of a mat. resistant to the chemical action of alkali metals and vapors thereof.

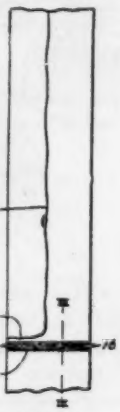
Method and apparatus for drawing sheet glass. ENOCH T. FERNGREN. U. S. 1,547,910, July 28, 1925. The method of producing sheet glass consisting in congealing a layer or sheet of semi-solid glass on the surface of a pool of molten glass, floating this sheet of glass horizontally on the fluid glass there beneath, drawing the sheet over an elevated mass of fluid glass near one side of the pool, and cooling the surfaces of the sheet as they leave the pool.



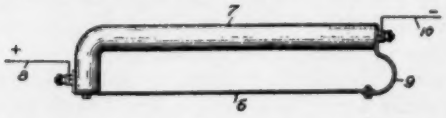


Glass furnace. ENOCH T. FERNGREN. U. S. 1,547,911, July 28, 1925. In a glass working mach., a container for molten glass comprising a lining of refrac. clay, and an outer supporting shell of silicon-carbide.

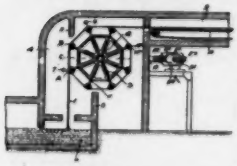
Method of interrupting longitudinal cracks in glass-sheet drawing. HARRY G. SLINGLUFF. U. S. 1,548,104, Aug. 4, 1925. The method of stopping a progressive longitudinal crack in a continuously drawn sheet of glass which consists in applying transversely of the sheet in advance of the crack a strip of fabric.



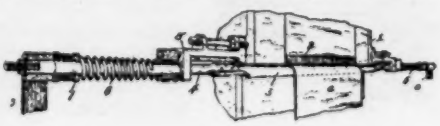
Process of severing glass. JOHN A. SWEET. U. S. 1,548,108, Aug. 4, 1925. A method of severing a glass article while said article is maintained at a relatively high temp. to prevent cracking thereof, which consists in applying to the article an electrically heated severing element maintained at a temp. such and applied for a period of time such that it melts its way through the glass.



Apparatus for drawing glass. CLARENCE M. BROWN. U. S. 1,548,114, Aug. 4, 1925. In combination in sheet glass drawing apparatus, a receptacle for a glass bath, a reel over the bath having a plurality of spaced drawing corners, which corners are arranged to act successively as drawing means for the glass, and means for so rotating the reel that each corner thereof during its period of draw moves at a substantially constant vertical speed.

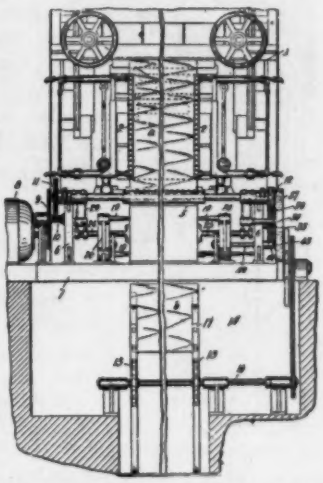


Manufacture of glassware. ROBERT M. CORL. U. S. 1,548,444, Aug. 4, 1925. In an app. of the class described, a thin, flexible member of chromium alloy in formative contact with moving glass while the latter is in a formative condition, the member forming the resistance-heating element of an electric circuit and having a sharp tip portion projecting in

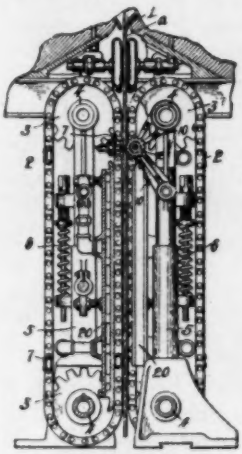


the direction of movement of the glass and from which the glass passes, and means for placing the member under longitudinal tension to maintain a true forming edge.

Manufacture of sheet glass. WILLIAM EMIL BOCK. U. S. 1,548,435, Aug. 4, 1925. In combination, a sheet section pressing means, means for feeding the lower end of a glass sheet into the pressing means, means for severing from the sheet a predetermined section disposed in the pressing means, and means before the pressing opern. for supporting the severed section in the pressing means and movable from section supporting position to allow the downward passage of the section after the pressing opern.

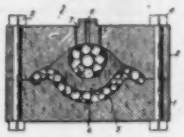


Sheet-glass-making apparatus. ROBERT M. CORL. U. S. 1,548,445, Aug. 4, 1925. In app. of the class described, clamping bars, means to move the bars in an endless path, one portion of the path being parallel with the path of a glass sheet being drawn and the bars leaving spaces across the sheet, said spaces being alternately short and long longitudinally of the sheet, and severing means mounted independently of the bars and adapted to act upon the sheet in said short spaces.

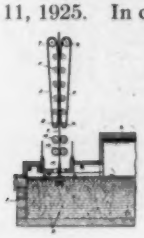


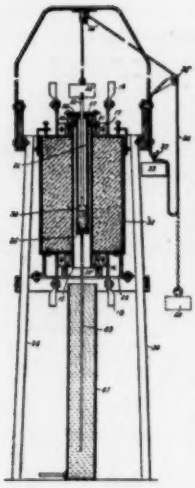
Bullet-proof glass. CONSTANTINE SHUMAN and ARTHUR G. WORRALL. U. S. 1,548,490, Aug. 4, 1925. As an article of manuf., a sheet of laminated glass comprising a relatively thick sheet of glass combined with a relatively thin sheet of glass secured to the surface of the relatively thick sheet of glass by a suitable binder filling the entire space between the surfaces of the glass sheets, and wherein the relatively thin sheet of glass is bent to conform to the general surface contour of the thick sheet and permanently held in such relation.

Quartz working. LEVI B. MILLER. U. S. 1,548,808, Aug. 4, 1925. The method of shaping quartz capable of conversion by heating to another modification of lower density which consists in confining said quartz in an enclosed mold in such quantity that when the quartz is heated to a temp. of plasticity the incidental increase of volume of said quartz will cause pressure to be exerted upon said mat., said mat. being so arranged that this pressure will cause the surface of the plastic mass to conform to the configuration of the mold.

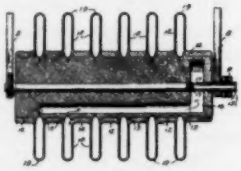


Apparatus for making sheet glass. HARRY G. SLINGLUFF. U. S. 1,549,513, Aug. 11, 1925. In combination with app. arranged so as to draw a glass sheet from an open pool of molten glass, of means for preventing inward movement of the edge of the sheet in said open pool, comprising a shielding member spaced above the surface of the pool but closely adjacent thereto and provided with a slot on its inner side into which the edge of the sheet extends, such member being of sufficient area and mass to retard materially the radiation of the heat from the area of the pool beneath it from which the edge of the sheet is drawn, and sufficient to retard materially the cooling of the edge of the sheet above said member.

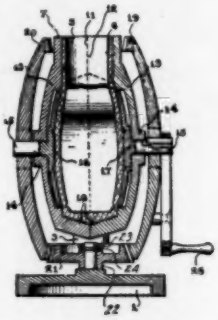




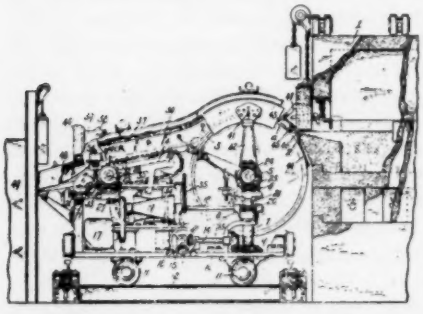
Silica glass. LEVI B. MILLER. U. S. 1,549,597, Aug. 11, 1925. The method of making shaped articles of transparent silica which consists in heating silica to a plastic state in a vacuum, the temp. being high enough to cause sealing over of cavities but below the temp. of active volatilization, removing the silica to a heating zone open to the atmosphere, and shaping the same under pressure while in a plastic state.



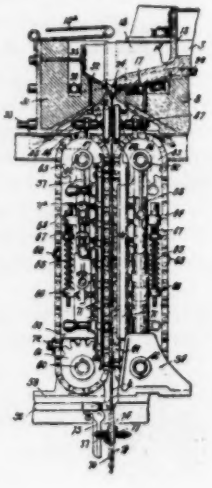
Method of and apparatus for forming glass sheets. WILLIAM E. HEAL. U. S. 1,549,541, Aug. 11, 1925. The method of forming glass sheets which comprises placing a layer of semi-fluid glass on the periphery of a gathering roll, revolving the roll to feed the glass outwardly by centrifugal force and form a pair of spaced sheets, and introducing air between the sheets during their formation to prevent collapsing.



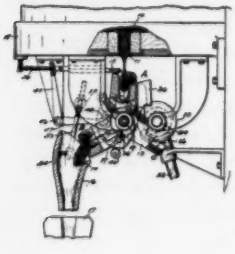
Molding flask. FRANK M. BIGELOW and ALBERT J. THROM. U. S. 1,550,492, Aug. 18, 1925. A molding flask for glassware blowing, comprising opposed complemental mold members having rotating bottoms having their inner faces provided with configurations for shaping the article to be molded.



Manufacture of glassware. ROBERT M. CORL. U. S. 1,550,427, Aug. 18, 1925. In an app. of the class described, a metallic heating element of high electric resistance having direct contact with a glass mass being acted on to effect a forming of glass at the point of contact.

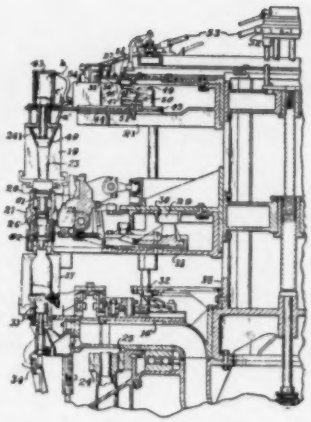


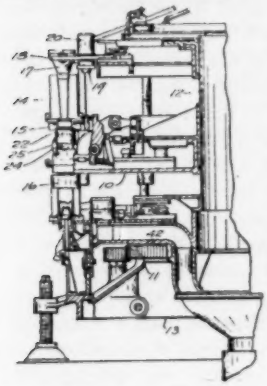
Manufacture of sheet glass. ROBERT M. CORL. U. S. 1,550,428, Aug. 18, 1925. The method of forming glass in sheet form, consisting in passing molten glass over or through a heated forming and finishing means downward from which the glass flows by gravity in sheet form, and supporting the central portion of the formed sheet from a point near the forming means to a point where the sheet is substantially set.



Mechanism for transferring molten glass. LEONARD D. SOUBIER. U. S. 1,550,397, Aug. 18, 1925. The combination of a partible gob-forming receptacle open at its upper end to receive molten glass, and means to invert and open the receptacle.

Glass-forming machine. ALBERT N. CRAMER. U. S. 1,550,346, Aug. 18, 1925. In a glass-forming mach. the combination of a split mold, a head adapted to enter one end of the mold, a stop plate and a piston motor, said head connected to the motor piston, the stop plate having a lost motion connection with the motor piston, said plate arranged to seat on the mold and arrest the mold-closing movement of said head.



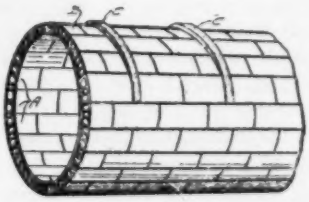


Glass-forming machine. ALBERT N. CRAMER. U. S. 1,550,152, Aug. 18, 1925. In an automatic bottle blowing mach., a finishing mold comprising laterally swinging body sections, a vertically swinging bottom section comprising a central reëntrant bottom member movable vertically in said bottom section while the latter is in horizontal position, and means to move said bottom section vertically while held in horizontal position.

Filter. TOKIO ELECTRIC CO. Japan. 4,429, April 22, 1925. The filter is made of porous friable quartz glass consisting of small grains of quartz fused together at the points of contact. S. K.

Heavy Clay Products

PATENTS



Segmental tile structure. WILLIAM C. FERGUSON. U. S. 1,549,078, Aug. 11, 1925. A sewer, conduit or other tubular structure constructed of segment blocks or tile and provided with beams or saddles arranged in the upper portion of the structure in such a way that they assist in carrying the load imposed on said upper portion.

Roofing tile. ICHITARO KAWASE. Japan. 1,939, Oct. 22, 1924. A plastic body made of clay, bittern and water is formed into tiles which are afterward fired in a tile kiln. They are then heated up to about 200°C and are painted several times with a mixt. of shellac-alcohol and copper powder about 200°C hot. The tiles are strong, water-proof and durable. S. K.

Process of manufacturing light brick. KAN HORIE. Japan. 2,607, Dec. 12, 1924. A mixt. of clay, sawdust and Kokaseki (a kind of pumice) is kneaded with addition of an aqueous soln. of resin soap contg. sodium silicate. Brick made of the body is fired in a kiln. S. K.

Method of manufacturing brick. TSUNEJI NAGATA. Japan. 3,899, March 25, 1925.—A mixt. of refrac. clay, ferruginous clay and iron powder is kneaded with addition of water. The body is pressed, dried and fired at high temps. The brick is claimed to be strong and non-absorbent. S. K.

Refractories

Optical method of determining the fusion points of refractories. ENRIQUE HAUSER. *Rev. Mat. Constr. Trav. Pub.*, **190**, 159–61B(1925).—By the use of a Féry optical pyrom-

eter H. detd. the fusion points of numerous refrac. mats. The pyrometer was sighted on the end of a molded stick of the mat., through an opening in a wall to minimize the extraneous light. The htg. was accomplished by means of an oxy-hydrogen flame. Seger cones heated at the base melted at temps. to within 10° to 20°C of their rating. The method is not adaptable for the m. p. detns. of oxidizable metals. L. N.

Properties of refractories with reference to metallurgical practice. W. GRUM-GRJIMAJLO. *Feuerfest*, **1** [1, 2], 3, 19(1925).—Discusses the corrosion of refrac. linings in metal fur. and methods of increasing resistance. (1) To prevent further shrinkage under operating conditions material must be burnt high enough to ensure stable vol. (2) Permanent expansion occurs only in poorly burnt silica brick where the change to tridymite involves a vol. growth up to 3.3%. In laying brick very thin joints should only be used in furnaces subjected to very high temp. where the temp. is above the softening point of the mortar. If the mortar is more refractory than the brick, use heavy joints which allow for expansion. Use of sawdust, charcoal and coke breeze recommended in place of quartz or grog as an addition to fire clay for mortar. This organic mat. burns away and leaves an elastic joint. (3) Refractory linings which soften under existing temp. conditions and melt together on the inner surface to form a solid wall offer good resistance as long as the temp. conditions remain constant. For conditions up to 700°C use common red brick with fire clay mortar. From 700–1200°C use clay-quartz fire brick. Up to 1450°C high grade refrac. clay brick are recommended and finally tridymite silica brick which will even stand up in arches at temp. of 1650°C. (4) Accuracy of shape and freedom from cracks depends mainly on careful prepn. of the body and handling before firing. (5) The action of metal slag is influenced not so much by the compn. of the brick as by the phys. structure and tridymite crystals unaffected by molten iron. (6) Heat condy. and resistance to temp. changes depend on the homogeneity of the mass and thorough firing rather than the use of coarse grained mats. Important steps in the manuf. of metal. refrac. are to burn grog to vitrification. Magnesite should reach 1600° in calcining. Use clay content of mixt. as low as possible and dry press method of molding. Addition to silica brick with 3% lime bond of 3% plastic red clay rich in iron recommended. Mach. pressing of silica brick not recommended, but addition of sawdust, etc., to increase porosity advisable. The firing must be carried on slow enough to ensure a uniform change in structure throughout the brick and high enough to make certain that all chem. and phys. changes have been fully completed. F. A. W.

Classifying refractory clays. E. WEBER. *Feuerfest*, **1** [1, 3], 5, 27(1925).—The old and newer methods of testing fire clay are discussed. Chemical analysis alone not sufficient but detn. of m. p., softening point under load and coeff. of expansion of importance. F. A. W.

The refractory nature of common high temperature oxides. J. BRONN. *Feuerfest*, **1** [3], 25(1925).—Nearly all high refrac. mat. used are in the form of oxides, *i. e.*, Al_2O_3, CaO, MgO, SiO_2, and Cr_2O_3, FeO, Fe_2O_3, TiO_2, ZrO_2. The need for closer investigation of the properties under high temp. of this latter group is brought out and now made possible by the development of the elec. fur. F. A. W.

Refractory materials for coking chambers and gas plants. L. LITINSKY. *Feuerfest*, **1** [4], 37(1925).—Entire range of refrac. mats. can be classified as follows: (1) Silica brick (high silica content) including such with lime or clay bond, Dinas, puddingstone, ganister brick. (2) Chamotte brick (high alumina content) such as clay-grog, bauxite and corundum brick. (3) Silica-chamotte brick, having a clay base with the addition of free silica as well as grog. (4) Clay brick made of sandy clay and without grog. (5) Carbonaceous brick, made of graphite, carborundum, etc. (6) Unclassified containing special oxides, *i. e.*, magnesite, chrome, zircon, etc. Basic brick depend

for refractoriness on oxides and contain no free silica. Al_2O_3 content runs 35–40%. Acid brick depend for refractoriness on high SiO_2 content of 93–97%. Brick, the acid or basic qualities of which are not strongly pronounced, are considered as neutral. For the industrial conditions under consideration only bricks under 1, 2 and 3 are suitable.

F. A. W.

Automatic machinery and equipment for a firebrick plant. R. WEBER. *Feuerfest*, **1** [6], 57(1925).—Describes and illustrates with diagrams, a plant using as raw material very hard shale clay and grog. Preparation of shale (1) jaw crusher (2) ball mill (3) storage bins. Prepn. of grog (1) jaw crusher (2) screen (3) crushing rolls (4) horizontal rotary separating screen (5) storage bins. Material handled continuously by conveyors and bucket elevators. Mat. from bins is automatically proportioned and carried to a mixing and humid trough and from there to a pugmill furnished with automatic cut off. The blocks are then sent to the handmold or repress department. F. A. W.

On the thermal changes of magnesite. YOSHIAKI TADOKORO. The Research Lab. of the Iron Works, Yawata, Japan. *Report* **4** [2], 58 pp.(1924).—Thermal changes of two typical cryst. magnesites, produced in Daisekkio, Manchuria, and widely used in Japan, are reported. Chem. compns. of specimens varied widely, two examples being as follows:

	SiO_2	Al_2O_3	Fe_2O_3	$CaCO_3$	$MgCO_3$	Accessory constituents.
White magnesite	16.62	0.32	0.72	0.90	81.42	Talc and org. matter.
Blue magnesite	20.02	0.14	0.14	0.60	79.03	Serpentine, talc and considerable amt. of org. matter.

Some specimens contd. only 1% of silica. I. Introduction. II. Change of compressive strength in htg. The strength of the magnesites diminishes with progress of dissocn. and shows slight increase at 1300°C. III. Change in wt. observed by thermobalance (0–1400°C). Slight decreases in wt. occur at about 120° in white magnesite and about 200° in blue, probably owing to the expulsion of water. Dissocn. of $MgCO_3$ begins at about 400° and nearly ends at 850° in both specimens. The rate attains its max. at about 600°. Similar expt. on talc is described. Talc loses about 0.5% of its wt. at 80–350° and about 5.5% at 800–1150°. The max. rate of dissocn. is shown at 1000°C. Chapter IV. Change in coeff. of exp. (0–1600°C). White specimens expand gradually up to 650°C, then they begin to contract, probably owing to the thermal dissocn. They show a slight but sudden contraction at 950° where $CaCO_3$ in the specimens dissociates. They contract about 3.3% in length at 1300–1450° where crystn. of amorphous MgO occurs. Slight changes at 1450° may owe to the crystn. of amorphous CaO. Blue specimens show a slight but sudden expansion at 350–450°, probably caused by the combustion of org. matter. Abrupt changes occur at 650° and 950° as white magnesite. Sudden contractions take place at 1250° and 1450°. Cooling curves of both magnesites indicate no sign of transition points. Linear contractions of two white specimens were about 4.5% and 7.0% at 1600° which became after cooling to about 6.5% and 10.0% resp., while those of two blue specimens were about 0.5% and −0.2%, increasing to about 2.5% and 1.7% resp. after cooling. V. Detn. of transition points by thermal analysis (0–1300°C and 0–1600°C). (1) Thermal analysis at 0–1300°C by differential method. Blue magnesite and alundum powder were used as sample and neutral subs. resp. Endothermal change began at 513° and the difference rate attained its max. at 652°. The temp.-difference began to decrease at 687°, its rate becoming max. at 757°, and came to normal state at 800°. No change was observable at temps. where $CaCO_3$ in the sample must dissociate. Similar expt. on Iyo dolomite is described. Here the endothermal reactions occurred at 710° and 870°

the max. difference rate being shown at 810° and 950° respectively. (2) Thermal analysis at 0–1300°C by inverse time curve method. Inverse time curves, *i. e.*, curves showing the relation between temp. and time required for raising 10°C, are given for white and blue samples. In white magnesite, a slight endothermic change occurred at 300–430°C, probably owing to the decompn. of org. matter. A strong heat absorption due to dissocn. of $MgCO_3$ began at 520°, attaining its max. at 630°. A weak absorption was shown at 900–950°. It may owe to the dissocn. of $CaCO_3$. In blue magnesite, decompn. of org. matter, $MgCO_3$ and $CaCO_3$ is indicated to take place at 300–430°, 600–810° and 850–970°, resp. (3) Thermal anal. at 1000–1600°C by inverse time-curve method. An elec. fur. of Mo wire and a Mo-W thermo-couple were used. An inverse time curve of blue magnesite shows two distinct heat absorptions at 1280–1320° and 1420–1480° which owe probably to crystn. of amorphous MgO and CaO resp. VI. Change in chem. compn. and sp. gr. (0–1700°C). Water adsorption of the white and blue magnesites, heated at various temps., rapidly increases at the htg. temp. of 500°, reaches its max. at 700° and becomes zero at 1300°C. Apparent sp. gr. and hardness of fired blue magnesite are as follows:

Htg. temp.	0°	500°	600°	800°	1000°	1100°	1700°
Sp. gr.	3.0	2.9	2.7	1.5	1.5	1.6	2.8
Mohr's scale of hardness	3.5	5.5	3.5	3.0	2.5	4.5	5.5

VII. Change in micro-structure (0–1700°C). Thirty-six microphotographs with detailed descriptions are given. Refractive index of white magnesite increases regularly with htg. temp up to about 1280°C, then abrupt rise occurs. S. K.

Refractory bricks in coke-oven practice. G. E. JUNIUS. *Brennstoff-Chem.*, **6**, 139–43(1925); *Jour. Soc. Chem. Ind.*, **44B**, 485–6(1925).—Dalhausen fire clay contg. 90–93% SiO_2 was long used in Germany for coke ovens, but more recently, with the larger ovens now used, it has become necessary to use silica brick. Germany possesses two kinds of quartzite suitable for silica brick contg. 93–98% SiO_2, the one having the quartz grains embedded in a matrix, and the other a felspathic quartzite with quartz grains angular and interlocked. The former is more readily converted into tridymite and cristobalite than the latter on firing. The larger the quartz grains, the higher the temp., or the longer the time, necessary for conversion. American quartzites are instanced with grains $^1/_3$ mm. diam. German quartzites have lower softening pt. than American, due to the presence in them of orthoclase and muscovite, and a higher specific volume, 1.75–1.9, as compared to the Amer. 1.65. This is important in coking wet coals, as brick of high porosity is more readily damaged by water. The use of mortar made from broken silica brick or fused quartzite is recommended. H. H. S.

Microscopic relations of sulphide and silica in blast furnace and converter linings. T. C. PHEMISTER. *J. Geol.*, **33**, 275–85(1925). H. H. S.

The influence of phosphoric acid and phosphates on the rate of inversion of quartz in silica brick manufacture. W. HUGILL AND W. J. REES. *Trans. Ceram. Soc.* (Eng.), **23**, 304–61(1923).—It was found that there was no advantage in the addition of phosphoric acid either as pure P_2O_5 or as basic slag. H. F. S.

The preparation of pure zirconium salts from zirconium earth by means of phosphate. J. H. DE BOER. *Z. anorg. allgem. Chem.*, **144**, 190–6(1925).—The 2 impurities most difficult to remove are Ti and Fe. Since many earths can be found which contain only a trace or no Ti, de B. devotes his attention to Fe. Zr can be sepd. from Fe in large quantities by use of the double fluoride with K and NH_4, the oxychloride, basic and acid sulphate, phosphate, and finally by a method based upon hydrolytic dissociation. Of these methods, that in which the phosphate is pptd. is the most satisfactory. The Zr

earth is fused with bisulphate; this is dissolved in H_2O and filtered, and the mixed hydroxides are pptd. with NaOH. They are washed by decantation and dissolved in concd. HCl, in considerable excess. Zr is then pptd. with H_3PO_4, washed well with HCl to remove Fe completely, then with H_2O, and the phosphate is then dissolved in HF or KF, from which it is again pptd. with NaOH in a pure condition. The hydroxide is used in the prepn. of other compds. The phosphate pptd. is very probably the orthophosphate, rather than the pyrophosphate as some workers have believed. In the presence of strong acid the tendency is toward the formation of ortho salt. Phosphate pptd. in acid soln. shows no tendency to hydrolyze, and is more easily sol. in HF than phosphate pptd. in neutral soln. Zr can be sepd. from HF by fractional crystn. of the soln. of the phosphates in HF, or by crystn. from soln. in NH_4 or K bifluorides.

(*C. A.*)

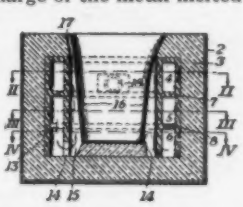
Refractories (for water-gas sets). W. M. RUSSELL. *Proc. Am. Gas Assoc.*, **1924**, 822–9.—*Crowns* have been successfully cast in place on water-gas generators, with suitable wooden forms and a mixt. of 10% Johns-Manville No. 3200, 8% anhyd. Na silicate, and 82% fire clay; after 6 months' service such a crown in a 6.5-ft. generator had not even checked. A *carborundum lining* for an 11-ft. generator has been in use by the Binghampton Gas Works since Oct., 1922, with a net saving due to decreased clinker troubles. The use of blocks about 0.5 the size of the usual fire-brick shapes has prevented trouble due to expansion and cracking, no trouble having been encountered due to oxidation, probably because their fuel is a good grade of anthracite with very low Fe. A diagram shows the construction of the lining in detail. *Bernitz blocks* have been in test and use by the Gloucester Gas Light Co. since May, 1922. These consist of hollow, inter-connecting shapes, with perforated inner walls, part of the blast (and reversibly the steam) passing through the blocks and into the fuel bed through these perforations. The cooling and mechanical action of the blast prevents adherence of clinker to the walls. These blocks are ordinarily carried to a height of 36–40 in. above the grate bars. For most purposes Mutton Hollow silica is satisfactory as a material, but for badly clinkering fuels carborundum has been used for making the blocks; no trouble has been experienced with their cracking or oxidation. Diagrams show in detail the construction of the linings. (*C. A.*)

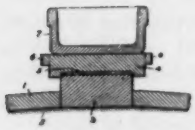
PATENTS

Composition for refractory wicks. CARL BUBERL. U. S. 1,546,616, July 21, 1925. A refrac. wick compn. of the class described including carbide of silicon and a binder.

Refractory article and method of making the same. CHARLES F. GEIGER. U. S. 1,546,833, July 21, 1925. A refrac. article containing silicon carbide, alumina and a binder produced by the reaction of said silicon carbide and alumina.

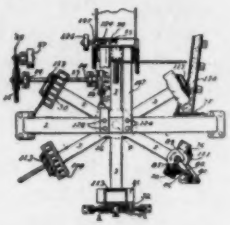
Crucible melting furnace. CLARENCE E. HAWKE. U. S. 1,547,872, July 28, 1925. A crucible melting fur., comprising a cylindrical outer metal shell having trunnions whereby the fur. is adapted to be mounted to tilt for the discharge of the metal melted within the crucible, a refrac. lining within said shell, a silicon carbide flue system within said lining, certain of the walls of which constitute the side walls of a chamber for receiving the crucible, and a crucible fixed within said chamber, said flue system comprising a plurality of superposed intercommunicating horizontal circular flues each extending substantially completely around said chamber, the upper flue having an admission port for burning gases and the lower flue communicating with said chamber at the lower end thereof, whereby the gases are compelled to travel a plurality of times about said chamber before being admitted thereto, substantially as described.

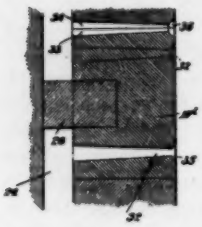




Pot seat. LEE SHOWERS. U. S. 1,548,103, Aug. 4, 1925. In combination with the arched clay floor of a pot fur. having an opening therein, of a seating block of refrac. mat. set in fixed position in said opening in the floor, the said block having a flat continuous upper surface adapted to engage and support substantially the entire bottom area of the pot.

Method of and apparatus for molding silica brick. WILLIAM ALLEN MILLER. U. S. 1,548,474, Aug. 4, 1925. The herein described method of molding silica brick which consists in taking up the mixt., letting it fall, and following its descent with a blow from above thus hurling it into the mold and causing it to push into all the corners of the said mold.





Furnace. WARREN C. DRAKE. U. S. 1,549,752, Aug. 18, 1925. A non-clinkering fur. wall comprising inner and outer portions, the inner wall built up of refrac. blocks constructed to afford air apertures directed into the fuel bed, such block presenting rear recesses adapted to receive separate spacing members, and separate spacing members engaged in such recesses of the inner wall so as to be supported thereby and to project rearwardly and contact the outer wall, to hold the walls spaced apart and maintain passages for conducting air to said apertures.

Process of manufacturing blocks for heat-insulation. THE TOKIO HOONZAI CO. Japan. 61,468, Oct. 22, 1924. Dry saw-dust is soaked with 2–5% soln. of a bicarbonate, preferably of sodium. A mixt. of 300 pts. of the wet saw-dust, 600 pts. of diatomaceous earth, 50 pts. of clay and 50 pts. of plaster of Paris are kneaded with 2–5% soln. of sodium silicate and syrup, in equal propn. Then the mass is formed into blocks which are fired at 800–1000°C. S. K.

Process of manufacturing architectural refractories. RIUKICHI AONE. Japan. 3,576 (Supp. to Pat. 719), March 6, 1925. A mixt. of powdered Kokaseki (a kind of pumice), calcined magnesite and asbestos, with or without addition of slag cement, is kneaded with soln. of magnesium chloride or magnesium chloride and aluminium acetate. The plastic mass is formed into required shapes. S. K.

Manufacture of refractory bricks, blocks or the like from dolomite or other materials or substances possessing plasticity at a high temperature. ANON. Brit. Pat. 223,616. *Quarry and Surv. and Contractors' Jour.*, **30**, 205(1925).—The improved method consists in molding the dolomite under press. at a high temp. and the resultant molded articles or material, after emerging from the molds, are annealed. It has been found, up to the present, that a temp. of 1500°C is most suitable for granulated sintered dolomite alone, or dolomite mixed with any known fluxing agents, for example, ferric oxide, clay or basic slag. The annealing process is carried out by automatically conveying the resultant molded article or material in an annealing or cooling chamber or tunnel, the cooling being a very gradual one. O. P. R. O.

Terra Cotta

PATENTS

Method of firing architectural tiles. HACHIJIRO MATSUMURA. Japan. 61,482, Oct. 22, 1924. A number of triangular pins are inserted into the holes in two opposite sides of a deep rectangular sagger, the holes being arranged stepwise. A glazed tile with four projections is set horizontally with the face down on each four pins. Then

a glazed tile having no projection is set with the face up on it. The projections are cut off after firing. S. K.

Process of manufacturing imitation granite. TOKIZO SANO and TERUKICHI SHIMIZU. Japan. 3,218, Feb. 16, 1925. A body, composed of ground granite, feldspar kaolin, soda-ash and water, is kneaded and pressed into tiles. On drying, white powder of soda-ash will appear on the surface of the tile. Then calcined sand is applied on its back and fired. Soda-ash serves in vitrifying the surface of tile and also in binding the applied sand. S. K.

White Ware

On puncture voltage of porcelain. TETSUJIRO TODA. The Tokio Industrial Lab. *Rept.* **19,** No. 1, 39 pp.(1924).—Puncture voltage of porcelain, composed of 30–70% clay, 10–50% feldspar and 50–80% quartz and fired at SK 9, 12 or 15 for 18, 22 or 26 hrs. resp., was studied. Source of clay was (*a*) Gairome (highly plastic kaolin), (*b*) Kibushi (ball clay), (*c*) Shirae (kaolin) + Gairome, (*d*) Shirae + Kibushi or (*e*) Korean kaolin (very pure kaolin) + Gairome. In testing, the porcelain disk, 14 cm. large and 5 mm. thick, was placed between a needle electrode and a steel disk in oil. Compns. which gave the best result in each group are as follows:

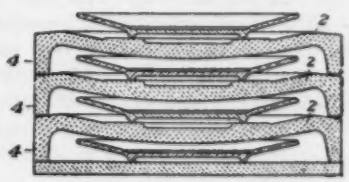
Group	Gairome	Kibushi	Shirae	Korean kaolin	Feldspar	Quartz	Firing temp.	Puncture voltage
a	50	..	..	..	40	10	SK 12	65,000
b	..	60	..	..	10	30	SK 12	67,500
c	25	..	35	..	10	30	SK 15	74,500
d	..	25	45	..	10	20	SK 15	76,800
e	25	..	..	45	30	..	SK 12	78,750

Conclusions: (1) The best results are obtained with bodies rich in lean kaolins and poor in plastic clays. (2) Shirae bodies are best fired at SK 15 instead of SK 12 in the other bodies. (3) Increase of clay in the body tends to raise the puncture voltage. (4) The highest voltage in a body is given at its min. apparent sp. gr. Expts. with bodies contg. magnesite, limestone or various frits, $RO.Al_2O_3.6SiO_2$, as flux failed to show any particular results. S. K.

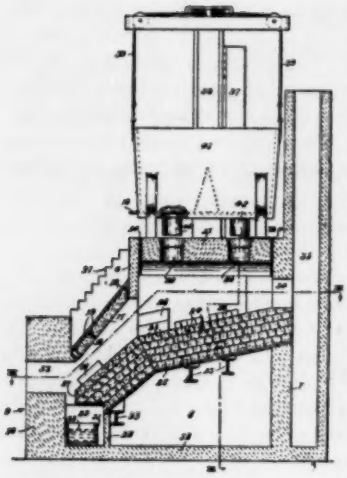
White glazed sanitary fireclay goods. W. THOMPSON. *The Industrial Chemist,* **1,** 91(1925).—White glazed sanitary fire clay ware may be considered as being a refinement of the stoneware manuf. T. gives a popular description of mfg. process. O. P. R. O.

PATENTS

Support for ceramic ware. FRANCIS W. HIGGINS. U. S. 1,546,382, July 21, 1925. A support for firing ceramic ware, consisting of a load-supporting plate or member combined with supporting legs or spacers, both the plate and legs being formed of a mat. having a higher modulus of rupture at 1350°C than 300 pounds per sq. in.



Method of manufacturing hard faience. NIPPON HARD FAIENCE CO. Japan. 60,699, May 31, 1924. Twenty to 23 pts. of zinc oxide or a zinc ore are added to 80–97 pts. of body materials for ordinary hard faience, to which a suitable amt. of a cobalt compd. has been introduced. The new body is fired, *e. g.*, at cone 1a. Advantages of introducing zinc compd. are: (1) it improves color of the ware; (2) it lowers the biscuiting temp.; (3) it prevents the ware from crazing. S. K.



Frit kiln. FRANK P. VOGEL. U. S. 1,550,474, Aug. 18, 1925. In a device of the type described, a kiln, an inclined bridge arranged in said kiln to form a heating chamber thereabove, a heat entrance leading into the chamber at the lower end of the bridge, a heat exit leading from the chamber at the higher end of the bridge, said chamber having an entrance for the mat. to be fritted formed in the top wall of the kiln above the upper portion of the bridge, the bridge having its lower end terminating in spaced relation with the adjacent wall of the kiln to form a molten frit discharge, a plurality of downwardly converging pairs of stays projecting above said bridge and forming a molten frit flow path extending longitudinally of the bridge, and a liquid carrying pan below said discharge to receive the molten frit.

New method of manufacturing pottery. TOKIJI UCHIDA. Japan. 60,647, May 15, 1924. Wares are made of a plastic body composed of ground magnesite, clay, pigment and water. For example, a mixt. of 50 pts. magnesite, 45 pts. Kibushi clay and 5 pts. rouge is used. After drying, the wares are fired for 3–5 hrs. at about 800°C and then dipped in a soln. of magnesium chloride (about 25°Bé) for several hrs. S. K.

Method of manufacturing talc potteries. KOSUKE HIRANO and SHINOBU KOMORI. Japan. 62,292 (Supp. to Pat. 40,863), Feb. 6, 1925. Talc, calcined magnesite and magnesium chloride are used as body materials. *E. g.*, talc 25, talc calcined at about 1250°C 30, kaolin or clay 30, feldspar 10, magnesite calcined at 800°C 3–5 and magnesium chloride 2–5 compose a body; 5–10 pts. of Sorel cement may be used in place of the last two materials. Wares formed of the body are glazed after drying and glost-fired. S. K.

Speedy weighing means more profits in industry. EARL STEARNS. *Nat. Glass Budget*, **41** [14], 3(1925).—Description of the Messiter Conveyor Scale which weighs and records the tonnage while in transit. F. G. J.

Equipment and Apparatus

Platinum resistance thermometry at low temperatures. M. S. VAN DUSEN. *Sci. Abst.*, **28** [6], 469(1925); *Jour. Am. Chem. Soc.*, **47**, 326–32(1925).—Below the region −40°C temps. defined by the Callendar equation depart from the thermodynamic scale by amounts which increase very rapidly below −100°C, the calcd. temps. being 2° too low at liquid-air temps. A simple modification of the Callendar equation for platinum resistance thermometry above 0°C is given, which will express accurately the resistance of platinum on the thermodynamic scale from 0°C to −190°C. The revised equation contains an additional term,

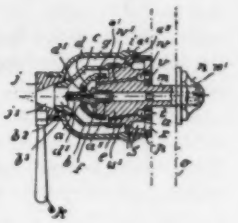
$$t = \frac{1}{\alpha}\left[\frac{R}{R_0} - 1\right] + \delta\left[\frac{t}{100} - 1\right]\frac{t}{100} + \beta\left[\frac{t}{100} - 1\right]\frac{t^3}{100^3}$$

The last term is omitted for temps. above zero. β is detd. by calibration at or near the b. p. of oxygen, and α and δ as in ordinary work. The new equation requires but one calibration below zero. Recalculations of data on resistance thermometers at low temps. obtained at the Reichsanstalt and the Bur. of Standards are made and tabulated showing

that the modified equation expresses the experimental results within the errors of observation. A. F. G.

PATENT

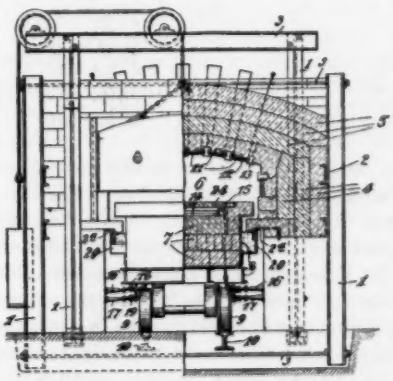
Method for spraying fusible material in continuous lengths. NICOLAUS MEURER. U. S. 1,549,843, Aug. 18, 1925. A method of spraying fusible mat., consisting in feeding the mat. forward in continuous lengths to a flame produced by the ignition of a combustible gas mixture, fusing the mat. in the said flame and finally atomizing the fused mat. by directing a jet of compressed gas into it at a point forward of the point of fusion.



Kilns, Furnaces, Fuels and Combustion

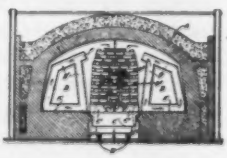
Advantages of the new method of constructing the Hoffmann continuous brick kiln. H. DE WIT. *Rev. Mat. Constr. Trav. Pub.*, **189**, 125–30B(1925).—Hoffmann kilns are still being constructed today in the same massive style originated 75 years ago. The usual arguments are refuted, namely (1) that the massive construction conserves the fuel. De Wit maintains that no more coal is burned in a kiln with walls 45 cm. thick than in one 3 m. thick, and that this point has been proved by actual comparisons in practice. (2) That a heavily built kiln insures a stable structure. The results of expansion and contraction due to heating and cooling are more noticeable on thick walls because there is more mat. to expand, and the walls usually do not contract to the original dimensions but leave interstices which widen with htgs. Another disadvantage is that the large cracks often establish air currents in the kiln, and these usually operate in an undesirable manner. The further criticisms of the old manner of construction are that the price of building is exorbitant and that the old kilns are bulky. An old kiln requires 700 sq. m. of ground as compared to 340 sq. m. for a new type having the same kiln capacity. The total masonry for the old kiln amounts to 2300 cu. m. whereas the new requires but 400 cu. m. with 25 tons of metal supports and parts. A number of sketches are given to help visualize the differences in construction between the two types. L. N.

PATENTS



Electric furnace. EDWIN L. SMALLEY. U. S. 1,547,623, July 28, 1925. An elec. fur. comprising a top portion, a base portion constituting a movable support for conveying the mat. to be heated, a heating element carried by said base portion, and means for energizing said heating element, substantially as specified.

Method of burning brick and analogous ware in tunnel kilns and car for burning the ware. PAUL A. MEEHAN. U. S. 1,549,143, Aug. 11, 1925. The improved method of heating ware in a continuous tunnel kiln which consists in supplying the main portion of the heat requirements of the kiln in the usual manner and separately supplying heat to secure a local heating effect obtained by burning fuel in proximity to the lower portion of the ware in the kiln along the central longitudinal plane through the kiln.



Roofing-tile kiln. MINOSAKU SUGIYAMA. Japan. 2,606, Dec. 12, 1924. In a rectangular kiln with fire-boxes at both ends, a latticed wall is built between kiln room and each fire-box. The kiln has two straight bag-walls with holes inside the latticed walls. Most of the flame will enter the kiln room upward through flues built under the kiln floor. Products of combustion escape the room through an opening at upper part of each side wall. S. K.

Roofing-tile kiln. SHUNTARO FUJIWARA. Japan. 2,250, Nov. 19, 1924. In a rectangular kiln with fire-boxes at front side, the flame enters the kiln room through three sets of holes in its front wall: (1) Several big holes beneath the kiln floor which make the flame enter the kiln room upwards; (2) Many small oblique holes built half way up the wall; (3) Several holes of medium size at upper part of the wall. The products of combustion escape the kiln room through holes at upper part of the rear wall and pass through a narrow room behind the wall downwards. S. K.

Tunnel kiln. TOYO TOKI CO. Japan. 3,570, March 4, 1925. A tunnel kiln, which has two combustion chambers with corrugated walls in its sides and fires the wares by means of hot circulating air, is connected with a drying arrangement in order to lead the dried air into the kiln at a point close to its mouth end. S. K.

Geology

Marketing lump and ground silica. FELIX EDGAR WORMSER. *Eng. Min. Jour.-Press*, **119** [10], 402–4(1925).—This article treats of vein quartz, quartzose rocks crushed to lump or powdered form and flint. Silica is hard, tough, resistant to acids, refractory and often transparent. Its chem. affinity for alkalis and other compds. is used in glass manuf. and the fluxing of ores. In massive form, silica is quarried and used as a packing in acid towers, made into grindstones or shipped to smelters to be used as a flux. Lump silica may be used in the manuf. of ferro silicon in the elec. fur. Ganister, silica rock, is used in the manuf. of silica brick which is widely used in metallurgical work. Flint, a cryptocrystalline variety of quartz of vitreous luster, is used in the form of pebbles as a grinding medium in pebble mills. Natural silica sand is used mainly in glass manuf. Sand for glass manuf. should be as pure as possible; iron oxide is especially undesirable. The limits allowable in common practice, as given by Cole, are:

	Per cent Fe_2O_3
Flint glass and soda-lime glass	0.02 to 0.05
Plate glass	.10 to .20
Bottles and window glass	.20 to .35
Dark bottles	.50 to .65

If the iron oxide content is not over 20%, the green color imparted can be neutralized by a decolorizer as Mn, Co, Se and Ni. Glass sands average over 99% silica. The character of the silica grains is an important factor. Uniformity in grain size is desirable for greater ease in melting. Exceptionably pure silica sand is used in the manuf. of carborundum. Crushed silica may be used for lining furnaces, converters and other smelting apparatus. Water-clear quartz crystals are now used to manuf. clear fused quartz. Commercial production has not yet begun, but the field for the use of clear fused quartz seems to be a large one. Powdered silica has a moderate industrial application. It is used mainly in the manuf. of paints, pottery, soaps, polishes, wood fillers, tooth powders, phonograph records, rubber goods and in dusting foundry molds and roofing papers. The prices of all silica products sold in raw form fluctuate slowly. Owing to abundance of the mineral and ease of production, prices are usually low. As in most non-metallic mineral production, uniformity of product is highly desirable.

A. H. K.

Recovering zircon from a zirconiferous pegmatite. R. C. GOSREAU. *Eng. Min. Jour.-Press*, **119** [10], 405–6(1925).—Zircon, $ZrSiO_4$, occurs in north central Wisconsin as pegmatite veins with igneous rocks of diorite with syenite. The dikes have a width at the outcrop of about 1300 feet and the strike can be followed for about 2000 feet. On the surface the pegmatite is much weathered. The zircon is high in alumina, 4% to 8%, while the oxide averages about 60.3%. The raw rock was crushed through a jaw-crusher to 1/4 inch and careful sampling showed 15.9% of ZrO_2 and 26.4% of $ZrSiO_4$. The 1/4-inch rock was ground to a minus 35- and plus 65-mesh product to release the zircon from the quartz-feldspar matrix. The product was concentrated on Wifley tables, a pure concentrate rather than a high recovery being sought. The final product had an analysis of:

ZrO_2	57.34	Al_2O_3 (free)	0.65
$ZrSiO_4$	95.00	SiO_2 (free)	4.80
Fe_2O_3	0.30		

This product, when dried and ground to 120-mesh, had a dull white color. The final product and concentration products from this treatment were studied, tested and found suitable for: (1) Brick for iron, steel and glass fur. linings. (2) Crucibles, muffles, combustion tubes and insulating tubes. (3) Surface cement for covering other refrac. mats. (4) Enamel pigment for iron and steel enamels. (5) Add to enamelware, silica- and stoneware to increase elasticity and strength. (6) To prevent devitrification in enameling. (7) Monolithic lining and patch material for elec. fur. (8) High quality refrac. obtained by fusing in elec. arc and regrinding. (9) A base for making pure zirconium oxide. (10) An ingredient in magnesia and alumina refractories. A. H. K.

Andalusite in California. JOHN MELHASE. *Eng. Min. Jour.-Press*, **120** [3], 91–4 (1925).—This article is based on observations incident to a trip to the Champion Porcelain Co.'s andalusite mine in the White Mountains of Calif. The andalusite is contained in a dike at an elevation of 8600 feet on the side of a canyon wall. Distribution of the ore appears to be fairly uniform with reference to length and depth along the dike but varies across the dike. Several thousand tons of ore have already been removed. After mining the ore it is broken to size, sorted by hand, put into bags holding approximately 100 lbs. and transported by pack train down a narrow mountain trail to a wagon road where it is dumped into a loading bin from which it is hauled by truck to the railroad. Andalusite forms from 75% to 80% of the mass of the ore mined. Shipments of ore, up to the Fall of 1924, had not exceeded 70 T. per week. Total probable cost of laying the ore down in Detroit at the Champion Porcelain Co. is about $43 per ton. The cyanite deposits of California have recently received considerable attention due to their easy accessibility and the large size of the ore bodies. At present they are owned by the Vitrefrax Co. Quartz is the chief gangue mineral in cyanite and has proved troublesome in concentrating. Recently a process has been devised, it is understood, that promises to solve the difficulty. A. H. K.

Antimony in China. ANON. *Chem. Eng. Min. Rev.*, **17**, 363(1925).—The decrease in antimony production in 1924 was due to heavy floods in Hunan province. Military movements and bandits also hampered transportation. M. E. M.

Production and properties of titanium oxide. R. H. MONK AND C. WHITTEMORE. *Can. Chem. and Met.*, **9** [7], 153(1925).—Describes the methods used at the large deposit at Ivry, Quebec, between Quebec City and Montreal for processing, removing the iron and calcining. Most of the output goes into white paint. It is also used as an opacifier in enameled ware. It is said to improve the qualities of fused silica. It has been used in making artificial teeth to give a slightly yellow color. F. G. J.

Bauxite. ANON. *Queensland Gov. Min. Jour.*, **26,** 219(1925).—The Commonwealth possesses vast deposits of bauxite, unexploited. The official announcement in France that a process for the economical manuf. of aluminous cement has been discovered in the Dept. of Herault, may hasten the development of Australia's bauxite deposits. O. P. R. O.

Bauxite, its industrial importance and its new applications. ALBERT HUTIN. *La nature,* **53** [1], 204–6(1925).—Descriptive. (*C. A.*)

Chemistry and Physics

Temperature limits employed in technical and scientific work. RUFF. *Quim. e Ind.*, **2,** 116(1925).—The fusion points of compounds, elements, oxides or combination of oxides, and carbides are given. The b. p. of the elements are given. The temps. are all above 1500°C except with the elements. Sixty-six different mats. were reported in the article. S. S. C.

Methods of measuring high temperatures. R. ESCAT-SERRA. *Quim. e Ind.*, **2,** 87(1925).—The apps. for measg. low temps. below 700°C are described and the theory of operation. The total radiation, optical and thermocouple pyrometers are described in detail and drawings of the instruments are shown. The article is only a review of various means of temp. measg. and does not bring forth any new methods. S. S. C.

The behavior of clays, bauxites, etc. on heating. III. H. S. HOULDSWORTH AND J. W. COBB. *Trans. Ceram. Soc.* (Eng.), **23,** 279–92(1923–24).—The shrinkage of clays on htg. takes place in a number of stages. Shrinkages of considerable magnitude occur at almost the same temp. in different clays, *viz.*, 530°C (except with ball clay), 880°, 950° and 1030–1060°. Changes in d., refractive indices and soly. in acids occur at these temps. Kaolin and fire clay lose water appreciably at 420–450°; diaspore at 370–400°; gibbsite at 160–190°; red bauxite at 350–410°. Gray bauxite loses water at 200–220° and 390–450°; allophane at 15–90°, 120–180°, 230–280° and 670–820°. Kaolin and fire clays show a distinct heat absorption at 500–530° and a heat evolution at 950°. Pure alumina gives heat evolution at 1060, and red bauxite at 1000. Heat phenomena accompany loss of wt. in many of the other subs. The change responsible for the exothermic effect in clay at 950, and that occuring with alumina at 1060 could be completed at 900 by continued htg. None of the heat phenomena observed in clays could be attributed to interaction between the clays and impurities. No evolution of heat at 950 was detected when alumina and silica of the compn. $Al_2O_3 + 2SiO_2$ were heated or when mixts. of the compn. $Al_2O_3SiO_2 + SiO_2$ were heated. H. F. S.

Synthesis and industrial manufacture of sillimanite. O. REBUFFAT. *Trans. Ceram. Soc.* (Eng.), **23,** 312–3(1923–24).—Sillimanite can be made by mixing hydrated alumina with kaolinite and gradually htg. the mixt. to 1400°C. H. F. S.

Results of X-ray investigation of the crystalline nature of china, clays, etc. G. SHEARER. *Trans. Ceram. Soc.* (Eng.), **23,** 314–7(1923–24).—Examination of china clay heated at 1200, china clay heated at 1700 and natural sillimanite gives almost identical lines in X-Ray photographs, indicating that the cryst. mat. in these heated china clays was sillimanite. China clay (1 mol.) and alumina (1 mol.) heated at 1200° and 1700°C and also china clay (1 mol.) and alumina (2 mols.) heated at 1200°C gave very similar spectra, indicating that in these sillimanite and alumina were the cryst. ingredients. However, china clay (1 mol.) and alumina (2 mols.) heated at 1700°C gave an entirely different spectra showing the presence of a new compd. of different characteristics from either sillimanite or alumina. Further work will be done on this compd. by S. H. F. S.

The action of heat on kaolinite and other clays. I. J. W. MELLOR AND A. SCOTT. *Trans. Ceram. Soc.* (Eng.), **23,** 322–9 (1923–24).—The dehydration of kaolinite does not

take place at a fixed temp. and is completed above 500°C. Kaolinite when heated to just above 500°C decomposed into free silica, free alumina and water. The critical point in the neighborhood of 900° is connected with a transformation in the form of the alumina. Sillimanite, the same compn. or the natural mineral can develop at temps. below 1200°C and probably above that temp. forms solid solns. with $3Al_2O_3.2SiO_2$. A new compd. is formed when kaolinite is heated to 1700°. This may be $3Al_2O_3.2SiO_2$, called mullite by Bowen and Greig (*Jour. Wash. Acad. Sci.*, **14,** 183). H. F. S.

The dehydration of kaolinite. J. V. SAMOILOFF. *Trans. Ceram. Soc.* (Eng.), **23,** 338–9(1923–24).—From a study of the htg. curves of kaolinite and other alumina silicates, S. concludes that in the process of dehydration kaolinite is decomposed into Al_2SiO_5 and SiO_2. H. F. S.

The thermal and electrical conductivities of some pure metals. F. H. SCHOFIELD. *Sci. Abst.*, **28** [6], 468(1925); *Roy. Soc. Proc.*, **107,** 206–27(1925).—Earlier research on thermal condy. has been over temps. from 100°C down to below −250°C, and the object of the present investigation was to extend to 700°C the measurements of thermal and elec. condy. of a number of metals of the highest purity obtainable commercially. The guard ring method was employed, steady conditions being obtained in the specimen and lateral heat losses reduced to low values. The specimen, in the form of a cylindrical rod, was heated by a Pt coil wound on a silica rod placed in a cavity at its center, and Cu rods screwed into its ends served as sinks. Various devices were employed to increase or decrease the heat losses from these ends. Temperatures along the rod were obtained with thermocouples of Pt and 10% Ir-Pt. An accuracy of 1–2% was obtained. Electrical condys. were measured by a comparison of the voltage drop along the specimen and a standard resist. in series with it. The results obtained for both conductivities and for Lorenz's function are compared with those of Jäger and Diesselhorst, Lees, Angell, Konno, and Honda and Shimidu. It was found that the thermal conductivity of Al increased with rising temp. Ni decreases at first, but above 500°C rises, while Cu, Mg and Zn show a slight decrease with rising temps. For Lorenz's function, Cu, Mg and Zn are practically constant at all temps. Al rises with increasing temp., while Ni increases up to 300°C, and is nearly constant above, with an abnormal value at 400°C. A. F. G.

Some new methods for the measurement of thermal conductivity. T. BARRATT AND R. M. WINTER. *Sci. Abst.*, **28** [6], 468(1925); *Phil. Mag.*, **49,** 313–22(1925).—In an earlier paper one of the authors has shown [see *Abstract*, 1991(1914)] that the thermal condy. of a thin rod can be expressed as $k = (H^2/pqhV^2)coth^2al$, or when the rod is long $k = H^2/pqhV^2$, wherein H = the heat supplied in calories per second to the hot end of the rod, at which the temp. difference between the rod and its surroundings is V degrees C; p = perimeter of rod in cm.; q = area of cross-section in sq. cm.; l = length of rod in cm.; $a = \sqrt{hp/qk}$; and h is the emissivity of the surface. The uncertain and troublesome part of the measurements required to determine k is that involved in finding h, since this factor depends on a number of important conditions difficult to take completely into account. The present paper describes new methods, based on those of the earlier paper, in which h is entirely eliminated from the formulas, thus removing the necessity for measg. it. The general equation for the fall of temp. along a rod is first solved in a general way, the soln. being transformed so as to give k in terms of H, q, a, V, and the temp. excess at any other point along the rod. The resulting expression is not explicit, but can easily be solved graphically, a numerical example illustrating the procedure in a typical case. From the general expression a simple formula for k is found requiring merely the measurement of H, the temp. at the hot end of the rod, the cross-section, and the temp. at any other point along the rod. Formulas are also found in the cases when (*a*) h/ka is small; (*b*) q, l, H, V and V', the temperature excess at the cold

end, are specified together with condition (*a*); (*c*) the ratio H/V is known for two values of l. Finally, a formula for h is found under the conditions specified in (*b*). A. F. G.

Action of electrolytes on clays. SEIJI KONDO. *Jour. Soc. Chem. Ind.* (Japan), **322,** 1315–46(1924).—I. Action of certain dyes on clays. (1) Introd. (2) Preliminary expts. on the adsorption of malachite green by various clays. Chemically pure HCl-salt of the tetramethyl di-p-amidotriphenyl carbinol was used. The amts. of the dye, adsorbed by 1 g. of 25 typical high-grade clays, are compared with their phys. properties which are closely connected with plasticity. Plasticity of 9 clays as measured by the adsorption of the dye did not agree with fact. (3) Estn. of malachite green. K. succeeded in estg. the dye by titrating with $KMnO_4$ or better with picric acid, whose results are far more accurate than those of the usual colorimetrical method. (4) The equil. of adsorp. of the dye by various clays. The results of expts. with 5 high-grade clays show that the Freundlich formula does not hold for the adsorp. of the dye by clays. (5) The elec. condy. of the dye solns. The elec. condy. of the dye solns. obtained in the preceding expts. and that of the pure dye solns. of various concns. were measured. The results show that the condy. of the pure malachite green soln. is not materially affected by treating with a clay. K. explains the phenomenon as follows: $C_{23}H_{25}N_2Cl = C_{23}H_{25}N_2^+ + Cl^-$; $M + C_{23}H_{25}N_2^+ = M^+ + C_{23}H_{25}N_2$; where M^+ is an equiv. of cation which has been combined with the clay; thus equiv. amt. of cation is set free from the clay and accordingly no remarkable change in condy. occurs. (6) The Cl content of the dye soln. The Cl content of the dye soln. is only slightly affected by the adsorp. (7) The effect of the proportion of water on the adsorp., those of the dye and clay remaining constant. The effect of the concn. of the dye soln. on the adsorp. is slight, provided that the ratio of the dye to the clay remains constant. K. assumes that the adsorp. is a chem. reaction. For the sake of convenience, suppose that the clay has only potassium kaolinate whose mol. formula is assumed as KA; then the reaction may be expressed by $KA + C_{23}H_{25}N_2Cl = KCl + C_{23}H_{25}N_2A$; if the mol. concns. of these subs. are m_1, m_2, m_3 and m_4 with degrees of ionization d_1, d_2, d_3 and d_4 at equil., we have the relation $m_1d_1 \cdot m_2d_2 = m_3d_3 \cdot m_4d_4$; since kaolinates are assumed only sparingly sol. in water, m_1, m_4, d_1 and d_4 may be assumed as constant; thus the equation becomes $m_2d_2 = m_3d_3$, which clearly explains the fact. (8) The surface tension of the dye solns. The surface tension of the dye solns. is affected by the adsorp. But no useful conclusion is deduced. (9) Adsorp. of the dye by clays, fired at various temps. Adsorp. of the dye by English china clay and Korean kaolin which had been fired at 110–1410°C was studied. Results: (*a*) Korean kaolin fired at 1300° has a strong adsorptive power which corresponds to 46.1% of that of the kaolin dried at 110°; (*b*) the color of the resulting sample fades rapidly as the firing temp. rises, and those fired at 1200° are only slightly green; (*c*) remarkable changes in adsorp. occur at 500° and 1200°, and a less marked one at 800–1000°, where thermal changes were assured to take place by Mellor and others; (*d*) fired kaolins rehydrate in moist atmosphere; (*e*) the fired kaolins do not adsorb Cl from the dye solns. (10) Adsorp. of methyl violet by clays. The results of the expts. with methyl violet 2B and the clays show that it can be used for measuring their plasticity; but, the fact that the dye-clay suspension clarifies very slowly is a serious defect of the dye. II. Action of inorg. electrolytes on clays. (1) Introd. (2) General description on the expts. 3–12. Adsorp. of KOH, $Ba(OH)_2$, K_2CO_3, KCl, $BaCl_2$, Fe_2Cl_6, $Fe_2(SO_4)_3$, $AgNO_3$, $MnSO_4$ and HCl by Korean kaolin. (14–24) Varying amts. of each electrolyte were added to 10 g. of Korean kaolin, one of the purest kaolins in the world, and 300 cc. of water; the mixts. were agitated for several hrs.; after settling, the clarified solns. were analyzed for each electrolyte, SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO and alkalis. Conclusions are: (*a*) Clay adsorbs inorg. electrolytes, just as it does dyes, and adsorbs considerable amts. of their cations completely, leaving no trace in the solns., as shown in the following table:

	Amts. of the compds. which 1 g. of the kaolin can adsorb in milli-equiv.	Amts. of the compds. which 1 g. of the kaolin can adsorb completely in milli-equiv.
$C_{22}H_{28}N_2Cl$	0.566	0.036
KOH	.634 + x	.027
$Ba(OH)_2$	.514 + x	.153
K_2CO_3	.432 + x	.000
KCl	.107	...
$BaCl_2$	.153	.052
Fe_2Cl_6	.287	.123
$Fe_2(SO_4)_3$	.374	.124
$AgNO_3$	.178	.027
$MnSO_4$	.205	.054
HCl	.357 + x	.108

(*b*) Only cations take part in the adsorp.; (*c*) The adsorp. is chiefly affected by the nature of anion and the soly. of the resulting kaolinate in water; as to the former, adsorp. of electrolytes with same cation decreases as the acidity of anion increases; as for the latter, adsorp. of electrolytes with same anion increases as the soly. of resulting kaolinate decreases; (*d*) Cations of the electrolytes displace the equiv. amt. of cations. The peculiarly rising inclinations of the adsorp. curves for some electrolytes owe probably to the presence of the kaolinates of several cations on the surface of clay; (*e*) General tendency of the adsorp. equil. is such that acid reacts first with kaolinates while alkali reacts first with kaolinic acid; neutral salt acts only to displace the cations of kaolinates. (13) The effect of dilution on the adsorp. Expts. with each 10 g. of the kaolin, each 0.1 g. of cryst. $BaCl_2$ and 50–1200 cc. of water show that the equil. is not materially affected by dilution; it is explained by means of the mass-action law. (14) Measurement of plasticity of clays by means of manganous sulphate. The amts. of manganous sulphate which were adsorbed by each 10 g. of 16 clays are compared with their air shrinkage, surface factor, tensile strength, binding power and plasticity-water. The result agrees better with fact than the dye. Moreover, the salt is obtainable in very pure state and can be estimated more accurately than the dye. S. K.

A process of purifying and utilizing waste ceramic raw mats. JIROKICHI KUMAZAWA. *J. Jap. Ceram. Assoc.*, **33** [386], 41–56(1925).—K. studied the purification of ceram. raw mats. by chlorine. The known method of bleaching them as they are by chlorine at high temp. is useless, because they are deprived of plasticity. Therefore the author tried the bleaching of formed bodies in biscuit firing. The following table shows the temp. ranges, in which typical Japanese raw mats. and bodies produce biscuits with suitable strength and porosity:

Gairome, Kibushi, Korean kaolin and bodies made of them.....	900–1050°C
Aizu-ware (liparite body, contg. small amt. of lime).....	900–950°C
Tobe-, Arita- and Kutani-wares (liparite bodies).....	1050°C
Amakusa stone (semi-decomposed liparite).....	1050–1100°C

Exptl.: A small coal-fired muffle kiln, 2′ high, 1.5′ wide and 1.8′ long, with two shelves was used, chlorine being introduced through a hole at the center of the door and drawn through two lower holes in it. Biscuit firing at 940°C was not satisfactory, though it was better than that at 800°. The firing at 1000°, the gas being introduced for six hrs., gave a better result. S. K.

Elasticity of minerals and its measurement. A. JOHANNSEN AND T. C. PHEMISTER. *J. Geol.*, **33**, 368–71(1925). H. H. S.

Combination of water in zeolites. V. ROTHMUND. *Rec. trav. chim.*, **44**, 329–

39(1925); *Jour. Soc. Chem. Ind.*, **44B**, 498(1925).—Discusses existing data concerning the nature of the combined water in zeolites. Although cryst. in structure, zeolites closely resemble colloids like silica gel and permutite in their behavior. H. H. S.

Pentaborates: a new type of alkali borate. V. AUGER. *Compt. rend.*, **180**, 1602–4(1925); *Jour. Soc. Chem. Ind.*, **44B**, 498(1925).—Solns. of B_2O_3 and borax, or potassium tetraborate, are fractionally crystd., resulting in a deposit of microcryst. prisms of compn. $R_4B_{10}O_{17}$, $5H_2O$, or, as the author thinks more likely, $R_2HB_5O_9$, $2H_2O$. H. H. S.

The measurement of the density of porous and pulverulent substances. O. SCARPA. *Ann. chim. applicata*, **14**, 360–7(1924).—The inconveniences and inaccuracies of the ordinary pycnometer and volumenometer methods are overcome by new forms of app. *Pycnometer.* The dried substance is weighed in an ordinary pycnometer and the latter is put in a desiccator with a ground-glass air-tight cover. Through a rubber stopper in the cover runs a funnel, the stem of which is drawn out almost to a capillary. This fine open end leads into the mouth of the pycnometer directly over the substance. Where the stem of the funnel flares into the cup of the funnel is a plug, preferably a rod with a rubber end. The desiccator also has a side-neck so that it can be exhausted by suction. With the pycnometer in position the system is sealed and the desiccator is exhausted for about 1 hr. The cup of the funnel is then filled with H_2O free of air and the plug in the funnel is opened so that H_2O runs in drop by drop and fills the pycnometer, suction being continued. The method is otherwise the same as usual, but is more accurate because of more nearly complete removal of air than long boiling. *Volumenometers.* Two new types are described, which in form and in operation are too complicated for a brief yet adequate description. They are described and illustrated in full detail with the mathematical principles involved, and the original should be consulted. The second is essentially an improved modification of the Oberbeck volumenometer (cf. Lo Surdo, *Nuovo cimento*, **12** (1906)). (*C. A.*)

Mechanical thermostats. J. R. ROEBUCK. *J. Optical Soc. Am.*, **10**, 679–90 (1925).—A critical review. (*C. A.*)

Design of a thermocouple for measuring surface temperatures. J. G. KING AND A. BLACKIE. *J. Sci. Instruments* **2**, 260–4(1925).—The instrument is used for measuring surface temp. of boilers, etc. and is accurate to 5° in range from 80° to 160°. (*C. A.*)

The crystal structure of the high-temperature form of cristobalite (SiO_2). R. W. G. WYCKOFF. *Am. J. Sci.*, **9**, 448–59(1925).—By means of powd. crystal spectra and the theory of space groups the unit cube of high-temp. cristobalite is found to contain 8 mols. of SiO_2 in the at. positions 8*f* and 16*b* (cf. Wyckoff, "The Structure of Crystals;" cf. *C. A.*, **18**, 3531); $a_0 = 7.12 \pm 0.01$ Å. U. at 290–430°; $d_{290} = 2.20$; closest distance O-Si = 1.541 Å. U. The absence of discernible mols. in this form of cryst. silica and the distinctly lower scattering power per electron of O as compared with Si are discussed. (*C. A.*)

The surface tension of clay slip. WO. OSTWALD AND W. RATH. *Kolloid-Z.*, **36**, 243–8(1925).—In some respects doughs and magmas such as clay slip are like solids, in others they are like liquids. Clay slip will pass through small tubes and form drops at the end of a tube as liquids do. The app. used to det. surface tension was a stalagmometer with tubes 0.5 cm. in diam. The tip from which the drops fell was enlarged on the outside and the bore almost closed at the tip. By means of a 3-way stopcock at the upper end of the tube, suction for drawing the slip into the tube, or pressure for causing it to flow out uniformly could be applied and regulated. The equations used were $\sigma = k_1.g$ (1); $g = dv$. (2) $v = k_2.Z^{-1}$ (3), where σ = surface tension, d = the density, v = the vol. of a drop and Z = the no. of drops in the vol. of the stalagmometer: and $d = k_3c$ (4), if it is assumed that density is proportional to concn. c. From these σ =

$k_4.d.Z^{-1}$ (5) or $\sigma = k_5.c.Z^{-1}$. The rate of formation of drops was not given, and no correction was made for the shape of the drop. For 3 kinds of clay the drop nos. for all concns. decreased when subjected to mech. treatment. As the concn. of any clay is increased the drop no. increases to a max., when the concn. is between 15% and 20% and then decreases. These phenomena are explained by assuming a structure in the water-clay mixt. Deformation of this structure in the inner part of a body is opposed by viscosity; surface deformations are opposed by surface tension. Each increase in surface disturbs the optimum arrangement of particles. (*C. A.*)

The general building plan of matter in the colloidal state. I. The form and the chemical composition of dispersed particles in suspensoid solutions and precipitates. P. P. v. VEIMARN. *Kolloid-Z.*, **36**, 237–40(1925).—The idea, that colloidal particles are composed of complex chem. compds., recently enunciated as new, has been used by V. for 18 years. About 20 references are given to confirm this. This idea had led to the following ideas regarding the precise form of colloids. (1) The particles of suspensoids are ultramicroscopic crystals, or aggregates of the finest ultramicroscopic crystals. (2) These aggregates may contain only one kind of crystals or more than one kind. (3) These crystals may grow in size and to various shapes, especially long needle-shape. (4) The aggregates will have a more or less rounded shape and be formed like a flake or a feather. The chem. nature of colloids is given under 12 heads: (1) When some substance X adsorbs some other substance Y, the compn. of the outer layers will be XY. If the crystals of X are large the proportion of Y will be negligible. (2) If the particles are progressively made smaller the value of Y increases and may become relatively large. (3) The cause of the sorption may be the same as the cause for the formation of complex compds., or it may be the formation of an insol. ppt. with the surface of the particle. (4) When the particles are very small so that the surface layer is the major part of the particle, one cannot draw a sharp line between the 2 classes mentioned in (3). (5) An aggregate of crystals in whose pores is the dispersion medium and all it carries will be yet more complex in nature than any single crystal. (6) The collection of crystals into aggregates changes the compn. (7) As the crystals grow larger the amt. of enclosed material decreases and the crystals become relatively purer. (8) As the concn. of the "Dispergator" D increases, Δ in the formula $XD\Delta$ increases. (When equal vols. of $BaCl_2$, $(a + X)$ normal, and $MnSO_4$, "a" normal, are mixed, $BaCl_2$ is the "Dispergator.") When the excess of $BaCl_2$, X, is plotted against the life of the resulting colloid there is a max. life for mixts. for each value of a. On the 2 sides of each curve will be pairs of points representing colloidal particles of the same life period but of different compns. (9) Purifying colloidal particles by dialysis or any other method removes the "Dispergator," changes the compn., and makes any analysis futile. (10) Sizes of particles and compn. are changing continually. (11) and (12) As the particles grow, $XY\Delta \longrightarrow XY_0 \longrightarrow X$, or $\lim (XY\Delta)_{t=T} = XY_0 = X$. It is useless to talk of pure phys. or pure chem. theories. The theory is physicochem. (*C. A.*)

The equilibrium of the series cryolite-alumina. G. A. ROUSH AND M. MIYAKE. *Trans. Am. Electrochem. Soc.*, **48**, preprint(1925).—The soly. of Al_2O_3 in cryolite in solid soln. is found to extend to about 12% and of cryolite in Al_2O_3 to about 77.5%. These points are confirmed by metallographic examn. (*C. A.*)

Micrographic examination of the structure of clays. BERTRAND. *Recherches et inventions*, **4**, 825–33, 841–51(1923).—True mica does not occur frequently in clays, and the presence of alkalis must be attributed to some other mineral. As he cannot identify microscopically any such mineral, B. concludes that the alkalis were absorbed when they were liberated by the disintegration of the feldspars from which the clays were produced. (*C. A.*)

Calculation of the heating value of a fuel from its ultimate analysis. R. VONDRÁČEK.

Montan. Rundschau, **17**, 317–21(1925).—The usual form of the Dulong formula $Q = 81C + 290[H - (O/8)] + 25S$, where Q is the (higher) heat of combustion and the letters represent the % of the resp. elements in the fuel, is revised with the introduction of a variable coeff. for C, *viz.*, $Q = (89.1 - 0.062C')C + 270[H - (O/10)] + 25S$, where C′ is the % C in the pure combustible, *i. e.*, is C cor. for the ash, H_2O and S contents. This formula, unlike the usual one, holds over the C range 45–90%. The % error in the heat of combustion calcd. for various C-contg. substances is as follows, for the new and old expressions, resp.: Bituminous coal, −1.0 to +0.3, −2.2 to +0.9; brown coal, −2.0 to +0.3, 0 to −6.9; peat, +0.7, −7.2; wood, −0.3, −11.8; cresol, +0.1, +0.8; cellulose, −0.3, −13.6; crude oil, −0.5, +5.7. The (lower) heating value of the fuel may be obtained from either of the above expressions by addn. of the term −6 (% moisture). (*C. A.*)

PATENTS

Process for producing aluminum chloride. FRANK W. HALL. U. S. 1,549,766, Aug. 18, 1925. The process of making aluminum chloride that comprises heating acid sludge to render it liquid, mixing the liquid with powdered aluminum ore to form a mixt. containing the ore in suspension, coking the mixt. and chlorinating the product to form aluminum chloride.

Process of increasing plasticity of fullers' earth. INST. PHYSICS AND CHEMISTRY. Japan. 2,236, Nov. 17, 1924. In the process of kneading fullers' earth or a mixt. of fullers' earth and other minerals with water, a small amt. of oxalic acid or an acid oxalate is added. The acid or its acid salts deflocculate the earth and increase its plasticity. S. K.

Process of bleaching clay and rock powder. ATSUSHI MATSUBARA. Japan. 62,418, Feb. 17, 1925. A low-grade clay is put in a tank with a stirrer and 2–5 *N* H_2SO_4 is poured in. Then hydrogen sulphide is passed through the soln. which is heated to and kept at 50–70°C. Ferric compds. in the clay are reduced by the gas and are dissolved by the acid. In about $1^1/_2$ hrs., the iron, together with greater part of manganese and chromium, will be dissolved. Then the product is elutriated to get rid of undecomposed colored minerals and sands. Semi-decomposed liparite, pegmatite, quartz, talc, agalmatolite, barium sulphate, etc. may be treated in a similar manner. S. K.

BOOKS

The physical chemistry of igneous rock formation. London: The Faraday Society. Price 6s 6d.

Base exchange in soils. London: The Faraday Society. Price 5s.

A system of physical chemistry. Vol. II—Thermodynamics. W. C. McC. LEWIS. Fourth edition. Pp. VIII + 489. London: Longmans, Green & Co., 1925. Price 15s. H. H. S.

General

Raw materials of the ceramic industry. ANON. *Chem. Met. Eng.*, **32**, 618–20 (1924).—Lists work being carried on by the Bur. of Stand. on clays. M. E. M.

Pulverized fuel. DAVID BROWNLIE. *Chem. News.*, **130**, 355–8, 374–7, 387–90; **131**, 7–9, 22–4, 41–4, 53–6(1925).—A general description of the efficiency of pulverized fuel for elec. plants and the use of refuse fuel at colliery. B. gave data on several American plants and the efficiency of pulverized fuel in these plants. The use of a pulverized fuel from the low carbonization systems would be an outlet for the product which is at present nearly unusable. Low carbonization is a source of fixed nitrogen and is of interest to England. The article is to be continued and in the first part B. deals with electrical power plants utilizing powdered fuels and gives advantages and various systems of pulverized fuel manipulations. S. S. C.

Ventilation. E. R. LUDLOW. *Trans. Ceram. Soc.* (Eng.), **23,** 340–56(1923–24).—Advocates the use of natural draft ventilators, especially of a certain type, on potters drying ovens. H. F. S.

Casein silicate paint. C. H. BUTCHER. *Indus. Chemist,* **1,** 153(1925).—Casein silicate paint is a liquid or paste prepd. by mixing casein with sodium silicate; the casein is dissolved in caustic soda and stirred up with the alkali silicate and a sufficient quantity of diatomaceous earth, and is then passed through the paint mill. The product may be tinted by the addition of lime-proof colors up to 10%. Powdered asbestos waste is sometimes added for the production of fireproof paint. Ordinary casein paints in the form of a thick cream, which is diluted with water for use, are prepared by incorporating the finely powdered body with the pigment and then mixing this product with sufficient casein soln. Casein (100 pts.) dissolved in 92° Tw. soda solution (15 pts.) and mixed with kaolin or prepd. chalk (885 pts.), suitably pigmented, is a typical recipe. O. P. R. O.

Ceramics. C. C. KRAUSSE. *Proc. Am. Gas Assoc.,* **1924,** 615–23.—A brief general discussion of the methods in use in the ceramic industry and of the historical development of the industry. (*C. A.*)

PATENT

Rust-removing compound. JOHN J. VAN BUHLER. U. S. 1,548,495, Aug. 4, 1925. The metal cleaning compound comprising 24 parts by volume of raw linseed oil, 56 parts of denatured alcohol, 48 parts hydrochloric acid and 13 parts acetic acid.

CORRECTION

The price of "A Text Book of Glass Technology" by Hodkin and Cousen in the August *Ceramic Abstracts,* Book Review Section, was listed as $10.00. The correct price of this volume is $12.00.

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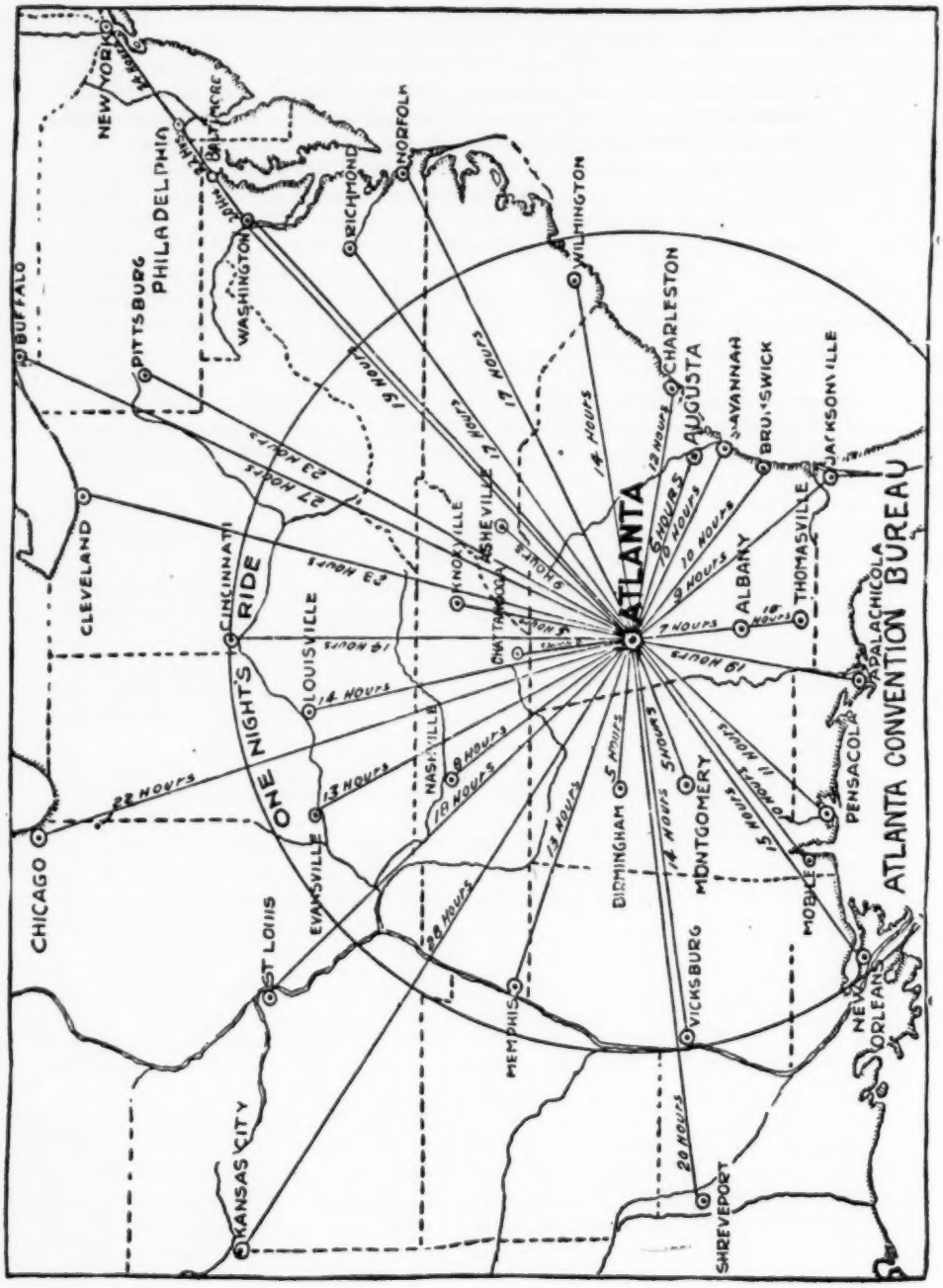

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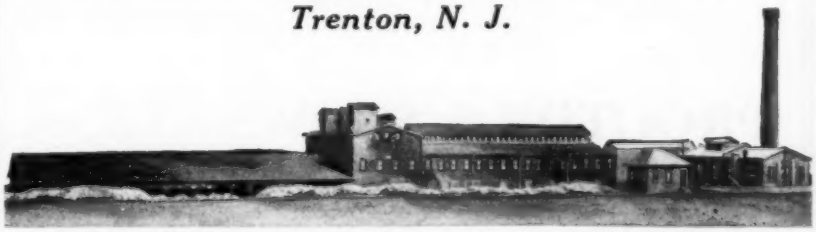

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BULLETIN

of the

American Ceramic Society

A Monthly Publication Devoted to Proceedings of the Society, Discussions of Plant Problems, Discussions of Technical, Scientific and Art Questions and Promotion of Coöperative Research

Edited by the Secretary of the Society Assisted by Officers of the Industrial Divisions

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EDITORIALS

CERAMIC EDUCATION

While preparing copy for this number of the *Journal* a new type of ceramic school is getting under way in East Liverpool and while this number of the *Journal* is in the mail members of this Society will be in conference in New York City on the question whether products and product requirements should be given more stress in the collegiate ceramic courses. During the past year Professor Greaves-Walker has gotten under way a correspondence course in ceramics. In the current literature there has been the suggestion that much of the inadequacy in American ceramics is traceable to lack of training and personal skill in the science and art of producing wares. University extension in ceramics has in some measure met the longing of many for aid in self equipment to serve better industrially, and aid in self expression in clay, glass and vitreous enamels; a longing born of a realization of deficiencies in ceramic processing and in ceramic products.

The Trenton Art School under Professor Fredericks, and other schools of like intent but with less facilities and support, have contributed quietly, but with sure results, in awakening a personal desire for more ability to produce finer quality and more artistic wares. Skill acquired in the collegiate and in the summer training courses in ceramic science and art conducted by Dr. Charles F. Binns at Alfred University con-

tinue to ripple on through the ceramic work of his pupils in the several art schools and regular day schools throughout the land, impressing not only the surface but also the depths of the demand and supply for more expressive and better wares. The ceramic art courses in Tulane University, Lewis Art Institute and in the several museums, and lately in Syracuse University and other institutions, are having a profound yet little realized effect on the ceramic purchasers and producers, individually and collectively.

The general question of the "how and what" of ceramic instruction is a natural outcome of the work already done by ceramic schools and is evidence of a growing need of the schools giving a close, open-minded study of how to produce distinctive wares economically. Schools must be as forward looking as any institution and particularly must they keep ahead of the heavy swells and back wash produced by their own propelling force. Ceramic schools and educational schemes are multiplying because students from the present schools have proven the value of special training and study. The present unusual and constantly increasing demand for better and less costly wares is one of the back washes of ceramic schooling.

Ceramic wares may be distinctive in the manner they meet service conditions or in the degree they satisfy and beautify; and schools cannot effectively train youths in methods of advancing ceramic technology and art unless the instructors search, experiment and explore the unsatisfied service and decorative needs.

The Art-in-Trades Club, the Art Division of this SOCIETY, the Metropolitan Museum, the Architects Leagues and Clubs of this country obtained new and larger visions at the Exposition Des Arts Decoratifs recently held in Paris and reported in the September number of this *Bulletin*. Each of these several groups has plans already for advancing the art quality in industrial products; awards and money prizes have been provided to excite individual and collective efforts.

Secretary Hoover has led in awakening researches in industrial waste of materials and labor, and in reduction of varieties and increase in quality of utility wares. Industrial associations and purchasers are in active accord with Hoover's program, all of which is reflected in the character, quality and definiteness in the activities of trade and technical societies and of the federal bureaus, state universities and technical institutes. Engineering experiment stations at several universities, with large sums invested in buildings, equipment and staff are in answer to this general-felt need for more economical production and more suitable product.

The employment this summer of the entire instructional staff with student laborers at University of Illinois Ceramic Department on industrial researches, making application to definite industrial problems the

facts revealed by scientific researches, is the sort of close working relation there must be between ceramic schools and the industries if the schools are to be up-to-date effective. School laboratories which are idle and school instructors who recreate for three or more months each year are not performing economically nor effectively, nor are they keeping up with the increasing demands for investigational and educational services. The schools have started something which will leave them discredited in their own wake unless their productiveness increases with their increasing demands. State and federal aids and industrial coöperation can be had in support of any and all educational enterprises which will enable manufacturers to get abreast more surely and more quickly with the increasing demands for more serviceable and more artistic ceramic wares. The several educational schemes for both intensifying and broadcasting educational means should be carefully studied by the schools.

NOTES ON CERAMIC ENGINEERING EDUCATION

By Hewitt Wilson[1]

A summary of most of the suggestions, objections and criticisms of ceramic engineering education now given in the several universities of the country is as follows:

1. The ceramic courses should be arranged to produce graduates who are better fitted to manufacture wares for definite purposes, and that products and product testing should be emphasized in preference to materials and materials mixing and testing.
2. That the ceramist needs training in "form, color and design."
3. That graduates should be better equipped to "anticipate service and market demands."
4. That the graduate should have more mechanical training in clay plant machinery. Too much time is now spent on glazed pottery.
5. That he should be given courses in psychology for executive positions and to handle labor.
6. That more attention should be paid to "factory management, including process control and human relations."
7. That more provision should be made for "elective courses in department of architecture, civil engineering, art and commerce. . . .to acquaint the graduates with the problems in the use and disposition of ceramic materials."
8. Suggestions for discussion are also made on the subjects of: courses, correspondence courses, radio lectures, preparation of texts, vocational training, etc.

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[1] Director Department of Ceramics, Univ. of Washington, Seattle, Wash.

At times, the discussion reminds us of the fable of the man, his boy and the donkey. They tried to please everyone along the market road by different methods of locomotion and ended their journey by carrying the donkey and pleasing no one. The structural products manufacturer wants a mechanical engineer with a veneering of ceramics of the fuel and combustion type; the terra cotta manufacturer wants a good glaze and color man; the pottery manufacturer who has developed his body and glazes wants a control engineer, artist or salesman; the enamel, glass and cement manufacturer wishes a chemical engineer for control by analytical methods and the refractory manufacturer must have a man skilled in high temperature products and testing.

In the past most of the ceramic schools have not been able to fill the demands or orders for graduates of general qualifications. In the past 20 years the qualifications have changed from time to time. In the early days, a greater demand was made for ceramic men to work in brick, tile and sewer pipe positions. Later, the terra cotta companies needed men trained in glaze and color work. It was not until the war period that the potteries wanted technically trained men for whiteware body and glazing problems. Now the refractory manufacturer needs research men for the specialized refractories. And with each demand for new qualifications have come the "repeat orders" from the other industries. Chemical engineers have taken a large percentage of the enameled metal, glass and cement positions, for these industries are more dependent on analytical control than the clay industries. With the cry raised for more attention to be paid to products and their disposal, it would seem that the manufacturing problems, save those of the control type, have approached solution. However, from the magnitude of the work on raw materials now under way in the U. S. Bureau of Mines, the Mellon Institute and even the Bureau of Standards, it is apparent that we are only nicely started on the fundamentals of our ceramic raw materials and methods of mixing, treatment and purification.

Present day ceramics is a wide and varied field of industry. No school can take a high school graduate and in four years give him a thorough grounding in chemistry, physics, mathematics and detailed studies, with accompanying laboratory work, in structural products, pottery, refractories, glass, cements, limes, plasters, enameled metals, insulation products and abrasives. It should also be remembered that the graduate is usually an immature boy, who must season awhile in the commercial atmosphere before he can become a very important or even a functioning part of the factory organization. Even in the less varied and more specialized electrical and mechanical branches of engineering, the larger manufacturing organizations give the graduate a six-month to a year training in special plant schools before they try to place them. The de-

mand in those organizations is for the fundamentals. They say, "We will give them the polishing. Do not try to crowd too much into a four-year ceramic course."

If all the suggestions noted at the beginning of this letter were to be given proper attention, it would be necessary to expand the ceramic department into a College of Ceramics with at least the four following options: (1) Ceramic Plant Engineering for the structural products, refractories, abrasives, etc.; (2) Ceramic Chemistry for enameling, glass, glazes and cement, and general chemical control; (3) Ceramic Art and Architecture for the artistic side of all the decorated wares and (4) Ceramic Marketing for salesmen, executives and business control. Each state university provides enough subjects in the other colleges or departments besides that of engineering to insure a well-rounded curriculum in each of the above options if the first two years were devoted to the engineering fundamentals. But the four options should not be lumped into one four-year course. The Illinois and New York schools have already divided their work into two options, but from the character and magnitude of the recent suggestions, one division does not yet appear to have solved the problem.

At the present time, the ceramic graduate does not know until the last month or minute, what kind of work he will enter. Our ceramic schools need better coöperation from the prospective employer (who is the consumer of the schools' product) if the manufacturer's interests are to be best served. Why cannot the manufacturer prepare and plan in advance for this most important raw material? If he sees a future need for one or more ceramic graduates, he should first get acquainted with the school and then from the junior or sophomore class pick out the type of individual he desires. If this student knows that he is associated with a certain organization which specializes in certain products, he will have a better incentive for his class and laboratory work. His thesis and all individual recitations and laboratory problems can be devoted to this direction. He will select his electives with the advice of his future employer and can spend his summer vacations in the direct employ of the manufacturer. The transition from school to factory will then be gradual. The alternative method places the responsibility of the specialized work on the student himself with the advice of the ceramic instructor. If any specialization is to be permitted, this is the opportunity for the manufacturer to state his requirements to individual students.

Emergency cases will have to be treated in a different way. The employer should pay for encountering an emergency without having planned for it. If he wishes to employ a graduate with the fundamentals and without special training in his industry, he then must do the extra training in his own factory or, as soon as convenient, pay for the specialized

education of the young man as a graduate student at a school where this specialty is understood.

This present agitation for investigation into ceramic education is long overdue. The ceramic instructor has for some time wanted the delayed coöperation of the manufacturer to avoid the last minute rush-order demands for graduates. If he has knowledge of the type of work the student will be expected to perform when he leaves school, he can give him many valuable coaching hints to tide over the transition period. But the plant manager should coöperate by forecasting his demands for technical employees at least for the same length of time he stocks other valuable raw material.

Products versus Materials

The direct criticism of the ceramic engineering schools because they do not spend more time with products and less with materials is premature. What has the ceramic industry known up to the present time about specifications and methods of testing finished products? Very little until it was awakened by competitive materials to the realization *that it thought it knew but couldn't put it on paper.* The common brick people are still asking the question, "What is a brick?" And a large number even with specifications are not trying to improve an inferior product. The terra cotta industry has been coöperating for seven or eight years with the U. S. Bureau of Standards in trying to write specifications for their product but they will not send any progress reports of this work to the ceramic schools to enable the instructors and students to follow the investigation. And the ceramic instructor has no data for specifications of terra cotta products unless he has some contact with the industry and can get the report in a roundabout way. This is a plain case of lack of interest in educational coöperation on the part of the terra cotta industry. On the other hand the refractory industry has been very frank about its troubles in deriving specifications and I do not believe that you will find a ceramic school which has not included in its regular course, studies on the compounding of refractory bodies to meet these specifications, together with the testing of products from commercial factories. Specifications are now being completed on pottery and other products which will be available for ceramic instruction next year and you will find that the schools will not be negligent in using them. On the other hand, consider the lack of specifications of our raw materials. And for that reason we believe that this recent criticism is premature.

Every ceramic instructor is worked to capacity during the school period and has practically no chance for research work in any line. During the summer time, unless he is employed by government agencies for research work, he is trying to make expenses by working on problems of another's selection.

It is true that the cement interests get far more advertisement in the engineering colleges than do the clay product organizations. This is because the cement interests have offered more coöperation. First, they have been united in their efforts for a long time, then they have studied their materials and associated products very thoroughly and have developed the use of their wares on an engineering basis and have assembled the data in an engineering way to enable the engineering instructor to readily impart it to his class and to use it for all types of problems dealing with structural materials. Similar work has not been done by the clay products associations who are younger and have not realized, until the present, the advantages of united research plus cooperation with the young men in the colleges. The Portland cement interests have passed the material studying and testing stage and for many years have devoted most of their time to products, products testing and sales exploitation. However, they have had an easier problem in material assembling and could apply chemical control methods to their manufacturing processes. As far as the writer knows, the Portland cement people have not been interested in the ceramic schools and have developed their manufacturing processes by others than ceramists. The introduction of new types of cementing materials into the market will draw their attention to materials again. The above illustration shows that the lack of interest in engineering circles to clay products cannot be properly laid at the door of the engineering or ceramic instructor who is primarily a teacher and not a research man. He must for the most part depend upon the industries themselves for the engineering facts about their products. Such facts will be readily assimilated by engineering curricula and will be assigned relative positions based upon their engineering importance as fast as they are collected and proven.

Such data have long been desired by the ceramic instructor. It has been awkward for him to develop a ceramic product from the raw materials to the finished state and then tell the class that according to the present knowledge it has value but that no engineering specifications have been devised for accurately placing it.

I do not wish to infer that clay wares are not tested in the laboratory as part of the student work. At the University of Washington (Seattle) a considerable part of our time has been spent in coöperation with the local industries by the testing of refractories, terra cotta, structural wares and pottery. But we have not had the coöperation from the national industries with national industrial research to determine the degree of perfection of these tests. We have progressed as far as any other laboratory of its size in devising methods of testing refractories and are now developing a fire brick spalling test with student help. However, the actual testing of materials according to specifications comes under the

classification of routine laboratory work, requires no originality or research ability and only laboratory manipulation. It should, therefore, be reduced to a minimum in the ceramic curriculum. The development of a method of testing a product or a material to reveal some particular property is a research problem because it involves original and creative thinking.

Accelerating and Improving Ceramic Instruction. 1. Lectures versus Recitation Courses

While it is true that ceramic instruction is handicapped by the lack of texts, it is also true that ceramic instructors have been teaching long enough to have their lecture notes in shape for mimeographing if not for publication in book form. Instruction by the lecture method, not accompanied by recitation is a slow, cumbersome method conducive to inefficiency and periodic spells of cramming on the part of the student, instead of a steady day-by-day preparation and systematic study. We have found at Seattle that we can cover far more ground and in a more thorough fashion by studying in advance for each lesson from mimeograph copies of the former lecture notes or from selected references in the literature. In this way, we have increased the amount of work covered each year and are ready for the new phases as they appear. Courses are made flexible and those portions, which from time to time decrease in comparative value, are relegated to the side lines for reference reading. This method imposes a greater load on the instructor. It takes more studying, planning and a greater knowledge of the subject to handle a recitation class than a lecture course.

2. Coöperation of University Instructors

In most cases, each instructor is a specialist in a few of the ceramic branches, yet he is trying to cover all of the field, in some portions of which he has had no practical experience. By coöperation and the formation of a working organization, the ceramic instructors of the country could each prepare a set of notes on those subjects in which they have specialized and distribute them to the other members for reproduction and use in class work. Such an association lies in the province of the AMERICAN CERAMIC SOCIETY. So far no attempt has been made to get together. This is due no doubt to the limited number, the personal character of the schools and the lack of appreciation that ceramic education is one of the vital factors in the ceramic industry. The educational committee of the AMERICAN CERAMIC SOCIETY no doubt had such an organization in mind when it started this recent agitation.

3. Teaching Resourcefulness

Since no ceramic curriculum can cover the details of the whole ceramic field in four years, we have to fall back upon the general fundamentals.

Prof. Watts' recent summary of the ceramic courses shows that this is the position of the schools today. The ceramic instructor has very little to do with the teaching of the engineering, chemical, physical or mathematical fundamentals except by a revision during the third and fourth years of those phases dealing with ceramics. But, if only the fundamentals can be covered in four years, the instructor should place the student in a position to be able to pick up the special details as he needs them in the industry. He should be familiar with reference reading, abstracting, and should know where to find data and how to separate the kernels from the shells.

Resourcefulness can be greatly accelerated in the laboratory courses. The laboratory problems should be standardized only in regard to the subjects covered and the methods of attack. Laboratory work should be made research work wherever possible. More stress should be laid upon methods of gathering data, assembling, outlining and planning work rather than covering a larger number of standardized laboratory studies which have been planned in detail by the instructor to save time for the student and work for himself. As the classes have grown in size, it has been natural to change from the individual contact method to the group contact and the individual student has suffered. When he gets into the industry he has no source of information save that which he can dig up for himself. No one lays out the work for him and such independence is disturbing to any immature graduate unless he has been taught self-reliance, resourcefulness and ingenuity. The question of introducing more work on ceramic products and methods of testing finished wares is a small one compared to that of teaching each student methods of forging his individual key to open doors into new problems. The university should not be considered a filling station but a training station.

4. Encouragement of Exchange Ideas with the Industry

The ceramic instructor can get better coöperation from his students in their thesis work if they know that their problem is one which has an immediate bearing on some commercial problem. The instructor should be in active touch with all phases of the industry, know the plants, the technical and executive managers in order to keep the school work up-to-the-minute in all ways. We keep on file a list of thesis subjects which have come from the factories. Contact, familiarity and friendship go a long way toward better coöperation and understanding, and ward off criticisms with their unfavorable advertisement.

5. Elective Courses

Enough elective courses (at least 8%) should be provided to enable the student to pick up a few fundamentals in business administration, economics, factory management, psychology, etc., so that he will be able to appreciate the financial, sales, cost and administrative side of our

industries and have enough of an introduction to this work to enable him to continue such studies after he leaves school. If more graduates were given the idea that while their college days are over, their studying days are to be continued indefinitely, we would have less trouble with them in the industry. They should be taught habits of study. Electives in art and architecture for training in "form, color and design" do not belong directly to an engineering education, although if a man knows that he will be employed by a manufacturer in which these subjects are essential, it would be well for him to choose some of them with his electives. Therein lies the difficulty. He can make a far better preparation for his future job if he knows what that job will be, but he cannot be expected to cover the whole ceramic field. We believe that the whole difficulty of the present situation lies in the lack of knowledge, understanding and appreciation of both sides of the question.

PAPERS AND DISCUSSIONS

A DISCUSSION ON "THE COMMERCIAL DECORATION OF GLASSWARE"[1]

By Theodore Lenchner

ABSTRACT

A discussion of art in connection with glassware as existing among the glass manufacturers of America, and a comparison with European manufacturers. The probable causes of this situation are brought out and a suggestion for the remedy is given.

This is a discussion of the commercial decoration of glass as practiced among American manufacturers of today. At the outset let me say that we, in the American Ceramic Society, are too often apt to think of art in terms of clay, when, as a matter of fact, glass can lend itself to artistic shape and decoration just as much as clay.

One of the largest manufacturers and decorators of glassware told me that one of the best selling articles they ever produced was a pair of candlesticks, in shape and design that of a Corinthian column, yet decorated with an Egyptian motif.

There are three fundamentals that the manufacturer must consider in creating a piece of decorative glass. First, the ease of applying the decoration, that is, the decoration must be simple enough that girls or men, without any artistic talent, can be easily taught to apply same. Second, the ware must be decorated in such manner as to require the least amount of operation or handling. Third, the decoration must appeal to the eye of the average buying public, and here is where the fault lies as far as real artistic production is concerned.

The standards of the average buying public, insofar as art in glassware is concerned, are very low. You, therefore, can conceive that this branch of ceramics needs considerable elevation also.

American glass manufacturers do not employ art directors as far as I know, but they do employ men capable of instructing others. There is one exception and this firm turns out a grade of decorated art glass which is beyond the reach of all the others and I dare say they conduct a more profitable business. Most glass manufacturers with whom I am acquainted, care nothing about creating a style of their own. They want something that will appeal to the average buying public, and that appeal at the present time seems to be a riot of applied color which clashes vehemently with what would be considered artistic color or treatment.

These pieces shown are not the production of American manufacturers. They show the difference between our commercial decorated ware and that which is produced in foreign countries. These pieces represent care-

[1] Presented at the Annual Meeting, American Ceramic Society, Columbus, Ohio, Feb. 1925. (Art Division.)

ful thought as to design, shape and application of decoration. Of course, this takes much more time to make, the cost of which the buying public would not pay.

Relief decoration, rarely produced in this country, has been built up by repeated application of enamel and fired. This is done entirely by hand and shows great skill.

MISS SHEERER: Are these fired more than once?

MR. LENCHNER: All are fired but once with the exception of relief enamel.

MISS SHEERER: In the case of that amber colored one, is that color on top of the glass or is it in the glass?

MR. LENCHNER: This is a yellow luster sprayed upon the glass, allowed to dry and a design in another luster rubber-stamped thereon.

MRS. WESTFELDT: Can you put two or three colors on at the same time?

MR. LENCHNER: Yes.

MISS SHEERER: The luster could be taken off without injuring the glass? Would it wear off easily?

MR. LENCHNER: Yes.

MR. ST. JOHN: Are the petals made and then set on?

MR. LENCHNER: No, the petals are simply painted with enamel and built up in layers and fired perhaps three or four times.

MR. ST. JOHN: I understand that they are making the flowers, then putting them on paper and firing the flowers first. The base enamel is then put under them thus overcoming the trouble of raised enamel boiling up or flowing out from underneath.

MR. LENCHNER: This is something that is giving the glass decorators some thought, inasmuch as they would like very much to imitate Wedgewood on glass. The relief enamel has a tendency to melt out of shape and this decoration (referring to glass with lily-of-the-valley clusters) is the best I have ever seen. Just exactly how this was done I cannot tell. Probably some of our Bohemian decorators could answer that question.

I might add that in this country there are few American decorators. The foreigners are very skilled in this work and they head most of our decorating shops. I am glad to state that some of our manufacturers have given this matter some consideration and have placed their own trained men at the head of their decorating shops. These men, while not trained in an art school, are sufficiently versed in the processes of treating glass and the application of vitrifiable colors that, for the class of decoration turned out in this country, their talents are sufficient. In many instances these decorators show originality and in lots of cases they are more suited to their work than the foreign decorators. This is probably due to the fact that the foreigner is not so well trained along the lines of quantity production.

MISS MARY L. YANCEY: Do they have any designers educated in this country, or would there be any chance for a young man or woman trained in art work design, to be employed in a factory of that kind?

MR. LENCHNER: I believe American manufacturers would welcome young men and women trained in art work design and would give them the opportunity to apply this design, after a course of apprenticeship in the various processes used in decorating.

MISS YANCEY: How should one go about learning the trade?

MR. LENCHNER: It is simply a question of apprenticeship under one who knows the various processes used in decorating glassware.

MISS YANCEY: That would have to be done in the factory?

MR. LENCHNER: Yes, as there are, unfortunately, no art schools or studios in this country, at least I have not heard of any. However, if you are willing to learn, I believe some of the manufacturers would be glad to give you the necessary training, provided you can do the designing.

PROF. COX: I would like to know if you could tell me how a little thing I saw in the Salon in Paris was made. It was glass, but there were partitions. It was a little bowl, and looked to me as though the glass had been cast in little pieces and then joined. The design was some little flowers, I do not recall just what. It was a studio piece of work. The quality of the glass was extremely fine. It was a very carefully compounded glass. It had a limpid quality that was most beautiful and which most glasses do not have.

MR. LENCHNER: In the foreign countries they do a good bit of casing of glass, and I believe that is the thing you are talking about. They will, for instance, gather a piece of crystal glass and superimpose over that a glass of another color. The coefficient of expansion of both glasses will have to be similar. Then they will cut through the superimposed glass, into the crystal glass, and give you these various effects.

PROF. COX: This was an enamel without any metallic backing. I have never been able to lay hands on a description of that process. It would be an ideal process to use in such schools as Miss Sheerer's. The results would be fine.

MR. LENCHNER: Our manufacturers do not very often case their glass. This requires great skill and we do not have the men trained in that art. There are one or two concerns that employ probably one half dozen men, well versed, and they are doing excellent work along this line. However, their art is different. They employ no vitrifiable color or stain, but depend entirely on hand manipulation of the glass which is known as off-hand ware.

PROF. COX: Is it possible to have a satisfactory literature on this kind of work? We have some works at our library at Ames that are not at all satisfactory. They are not sufficiently explicit, they are not technical, they are not written by a technical man, generally, but by an artist who is interested rather in the form, and entirely satisfied from that point of art. But when you want to go about doing a thing, the exact way will have to be stated.

MR. LENCHNER: I have searched through the libraries in the hope of finding some satisfactory literature, but could find it nowhere. There is nothing even satisfactorily described in European literature, for that matter.

PROF. COX: I wonder if you or your friends could be interested in that. First of all, if we are to help the industry we have to have a literature from which to teach. There is a literature in other lines. The brickyard literature has been built up by men willing to contribute from their experience. Are there trade secrets?

MR. LENCHNER: The processes used in decorating are more or less trade secrets. If you are really interested, I will put in writing some of the processes used.

PROF. COX: If you will give that kind of a start, the art schools will do their part. Some one from the Cleveland School of Art asked for help, wanted to know what they could do. This woman from Cleveland said they were out to serve the State of Ohio. If the manufacturers will suggest to them what training to give, they will be glad to give it.

Iowa is not a state for the production of glass, nor is likely to be very soon, although we have glass sand out there. If a person is interested in this sort of thing we have plenty of elective room in the senior year to permit the student to take up what he is interested in. We are building up along that line with the thought that if the industry will coöperate, give us what they have got to build on, we will in turn be glad to do what we can to help them.

MR. LENCHNER: I believe if you will take up that subject with the

glass associations directly you can get an idea as to how they feel about this, and they would probably assist you considerably.

PROF. COX: We want to make it plain that the artist is willing to become practical, to be instructed by the practical man. If we can get a man like you to come into this Division, I think the Division will function much better. These artists will after all be out looking for jobs to make a living and they want to know how to do the jobs.

SAGGERS IN THE EARTHENWARE INDUSTRY AND DISCUSSION

BY A. V. BLEININGER

Introduction

I thought I would start out the discussion by bringing out two points that might be of some interest in connection with saggers used in the semi-vitreous industry, and these points are quite obvious. In the rush of business which has prevailed for some years our plants got into the habit of taking sagger clay immediately from the car and putting it into the soak. After we had a better chance to improve things we insisted that under no circumstances should sagger clay be used direct from the car, but it should be treated in a certain way.

Preparation of the Clay

All we did was to get some sprayers (like lawn sprinklers) and from time to time we would give the clays a slight soaking. We found that it is not good practice to drown the clays, to give them so much water that they will become slimy on the outside, but to give them a smaller amount of water from time to time until the larger lumps begin to crack and fall to pieces. After the clay has reached that condition it will take more water, but the point is that under no circumstances should clay be used direct from the car without having undergone this treatment.

After this had been done for some time the saggers began to improve. They responded at once, which showed that in the hurry and rush of our previous work we had neglected this very important part of preparation. We all know that clay which is simply taken from the car and then put into the soak pit is in no shape to take water in the proper fashion, because it is not ready to receive it. This preparatory treatment outside should be given to all the sagger clays.

In one of our plants we have a wet pan. We introduced it simply because we thought that we would obtain with it a more thorough and satisfactory preparation of our sagger clays, but we have been quite disappointed with it. We have not obtained the results that we expected.

Even with the use of the wet pan we have found that the clay should be treated in the fashion which I have indicated. Even the wet pan is not sufficient to replace the long-time treatment with water, causing the clay to take up its water slowly and gradually but completely. The intensive treatment in the wet pan for ten minutes is not equal to the long treatment of first the preliminary soaking and then the final soaking, which we get in the old-fashioned process.

Rapid Cooling of Glost Kilns

Another point on which I would like to invite discussion is this, which also has to do with the hurry and rush methods which have prevailed in the pottery industry. This is the cooling of the kilns. Under the schedules which have been prevailing during the past few years the kiln was opened and the saggers were drawn about as fast as it could be done; in other words, very frequently a kiln was finished (a glost kiln I mean) and a hole was torn in the door and cooling started immediately, and in order to help things along if the schedule was slowing up they took a good-sized fan and blew cold air into it. That created conditions which are exceedingly hard on the saggers.

It seems to me this extraordinary fast cooling is one of the prominent factors connected with the high sagger losses. We believe that with slower cooling we reduce these losses considerably.

In discussing sagger clays and saggers we must recognize as one of the greatest factors the resistance of the sagger clays and the sagger mixes to sudden heating and cooling. This is a very important point in connection with the study of saggers.

Effect of Repeated Heating on Thermal Expansion

Furthermore, it has been found in the course of observation that the saggers changed in their behavior in regard to their resistance to sudden heating and cooling. One sagger mix used by us, when saggers made from it were used several times, showed a fair resistance to sudden heating and cooling but the older it got the more sensitive it became and the less the resistance to heating and cooling. I do not know just where but a point was reached not very long in the life history of the sagger when it became exceedingly sensitive and it cut, or broke in two. This increasing sensitiveness to sudden temperature changes is an important point, and we have been led to believe that some results might be obtained by studying these clays with reference to their thermal coefficient of expansion and the change of the latter upon heating a number of times.

We imagine this might be true: That a sagger when first fired has one kind of thermal expansion but when fired a second time and oftener this property changes very markedly. We should know how the sagger changes in its coefficient of expansion. We should know the change in expansion with the temperature, and with time, *i. e.*, repeated firing.

I have taken the liberty of trying to start a discussion, first, with reference to the preparation of the clays, by making use of the gentle soaking preliminary to the final soaking in the usual method of preparation. Second, the sensitiveness of the saggers to sudden heating and cooling; whether or not it might be possible to obtain better results by slower cooling. Finally, it would seem to be desirable to know something about the relation between the coefficient of thermal expansion, temperature and time.

Testing Sagger Clays

We have tested sagger clays forward and backward by all of the older, well-known methods, and it seems to me that we do not know any more about sagger clays than we did before. We know certain things. We know whether the clay is weak or strong. We know how it will hold up in the green state, whether it is refractory enough, etc. Those points we, of course, have established, but as to what life of the sagger may be expected, we cannot predicate, and we must look for some more definite criteria than we have now.

Some clays give poor results, although they may conform to the required drying shrinkage, fire shrinkage, porosity, etc., yet owing to some kink in the structure they are absolutely no good. I do not know the cause. That is the reason why I would like to get a discussion started as to methods by means of which we can get at the real facts in the case and get at some knowledge as to how the sagger clays will behave in the kilns and whether we could not by some such means as the thermal expansion study get at the real happenings within the sagger body.

Sagger Investigation

So far, our progress in the sagger studies has not been very illuminating. But we have some better perspective for further work. Some years ago the proposition was made that an investigation be started on saggers and sagger clays. I have been accused of not being enthusiastic about it at that time, and I must say that I am glad that we did not undertake the work then. Our viewpoint at that time was too brash, too self-confident, and we were too sure about getting something. As a matter of fact, I think the result would have been that we should have spent $25,000 and not had anything to show for it. I do believe that we have a better realization today of what we must look for; namely, not the exterior changes in the clay but those taking place in the interior, those molecular changes, which make good and bad saggers.

Discussion

R. A. HEINDL: I happen to be the member of the Bureau of Standards staff in charge of the sagger clay investigation and agree with Mr. Bleininger that as far as ordinarily determined physical properties are concerned

I also have found the correlation of results obtained very unsatisfactory. Mr. Bleininger, how long does this presoaking or sprinkling treatment cover?

A. V. BLEININGER: I would like it to cover as long a period of time as possible. It should be at least three weeks to a month. That depends on how fast the clay comes in, but if possible we would like to have it undergo this treatment for a month at least, during the summer and fall. In some plants we cannot do it at all in winter.

C. L. SAYRE: Would the preliminary weathering of the clay at the mine take care of the preliminary soaking?

A. V. BLEININGER: Yes, it would, but most sagger clays are not treated this way at all. They still have the mine moisture in them and they will not take water except very slowly.

T. B. ANDERSON: I entered the pottery business through a sagger shop, back in the early days. A large pottery firm started to make vitreous china. They found that they had made a serious mistake in underestimating the size of the sagger shop to take care of vitreous ware, therefore it was necessary for them to build an auxiliary plant which is still in existence as the Potters Supply Company. We put these sagger clays in bins in which there was no preliminary aging or sprinkling. We made saggers out of them for a china plant.

We had ample drying room and ample firing space, so we gave them lots of time. Those saggers were very satisfactory in the firing of chinaware and were used in the bisque kilns at the china works as long as they were making china. The size of the sagger shop and the methods of drying saggers are points I wish to emphasize. A good deal of the cause of structural weakness in saggers is because of the limited space and the method by which saggers are dried. All cracks in the saggers are usually vertical cracks of various degrees from the top edge to the bottom. Some appear very soon after the sagger is made, and some appear when they come out of the bisque kiln.

We all know that in the electric porcelain business there are large pieces that must go through humidifying. There are also millions of bricks made in this country that would not be gotten ready for the kilns unless mechanical humidifying driers had been constructed which heat the brick to an even temperature before the moisture is expelled.

In most sagger shops a sagger is dried quite dry almost half way down, and then it is turned over. It is natural that there is a structural strain in that clay before it ever gets into the kiln. That has always been the case, but more the case now especially in whiteware because very few of us (we have enlarged our capacity, increased the turnover of our kilns) have increased the capacity of our sagger shop. It is very often stuck away in some corner where it originally started.

So it seems to me that if we are going to have better saggers we shall

have to pay more attention to them. If these saggers were sold in the open market there is no question but what we would pay a lot more attention to their manufacture in trying methods of making them and firing them and there would not be such a loss. The method of drying them is one of the reasons for our big loss of saggers. If any one is using a humidifier or a drier of that kind I would certainly like to know their experience on this thing.

T. H. SANT: Mr. Sayre made a very important point when he talked about the clay producer weathering the clay before he shipped it. He is in position to do that usually much better and much more easily than the potter, because, except in such large institutions as the one Mr. Bleininger is connected with, there is no room to do that and usually they do not have the time to do it. If they run short of sagger clay, they get a car in and want to use it right away. The clay producer, if the manufacturer insists, will have it weathered. The manufacturer on his part should meet him part way and pay a little more for it. Naturally the increased cost has to be taken care of, but results can be obtained that way. I am thinking particularly now of one clay which is weathered for 12 months and the results obtained by that weathering are remarkable.

F. S. CRUMLEY: Some one raised a question about the saggers cracking from the top down. Is it his idea to retard the drying of the sagger in order to have more uniform bottoms? How would you do that?

T. H. SANT: Inasmuch as the bottom is protected by a board, the top should be covered to prevent a circulation of air on the inside and around the sides. That is done in some of the plants where they have large pieces. The ware is given quite a while to dry; they usually wrap it and put barrels over it. I am not as familiar with the latest processes. It has a tendency to heat the ware to an even temperature before the moisture is expelled.

F. S. CRUMLEY: It has been our experience that in retarding the drying of the sides of the sagger you eliminate those cracks.

A MEMBER: What should the original sagger firing temperature be in relation to the firing temperature of the product? I know of a number of firms that fire the product and saggers around cones 2 and 3. If they brought the ware to cone 8, I would want the original sagger firing to reach between 9, 10 or 11, or at least a couple of cones higher. That would have a bearing on the life of the sagger.

A. V. BLEININGER: Theoretically it would seem that we should fire the saggers to a temperature as high as that being used, or higher, but practically we do no such thing. We fire to cone 8 regularly but the saggers get the benefit of only cone 6. I do not know how high they should be fired to get the best results, but theoretically they should be fired as high or higher than the temperature to which they are being subjected in the regular firing.

H. GOODWIN: The question of saggers was discussed at our St. Louis meeting in 1922, at which time the statement was made by the superintendent of a whiteware plant that they did not fire their saggers at a very high temperature the first fire and supplemented it by saying that they had gotten good results. With this statement I took issue remarking that it was contrary to my experience, having always found it the other way about. Take, for instance, a sagger used in glost kiln having a high absorption will take up a greater volume of glaze wash, thereby affecting the contraction of the sagger as well as its life because the body would be denser and rapid cooling would affect the life. Such saggers vary in size when wadded; the wads would not remain in place due to the lack of weight, thereby admitting sulphur from the coal and air with the result that much ware is bad, especially so in all saggers containing flat pieces.

In a bisque sagger fired at a lower temperature the first time, it has not the strength to carry the load of filled saggers above it, with the result that the bottom pushes up, bulges out and bungs fall over like ten pins. The only way to get a good sagger is to fire the first time so that it will stand the strain.

The making of our saggers today in comparison with those made a few years ago is likewise a factor, therefore, not being made to the same degree of perfection we cannot expect them to give us the same life which they did years ago.

Some made reference to the $25,000 which was injected into the proceedings at St. Louis. I think it would be a good thing, yet I do not think the U. S. Potters Association should do it alone, because the subject is so far-reaching. Other industries in different parts of the country should be taken into consideration and should assist financially and otherwise. I would like to see some unified action taken whereby the manufacturers can use one test plant. I do not believe any one alone will solve this matter. We know the Bureau of Standards has been working on it with various clays.

W. L. SAMPLE: In regard to remarks on firing, the first firing or the green state should be a little higher than the temperature to which it is fired later on. I know I have had good results doing that. I can remember some eight or ten years ago a friend of mine in the pottery business told me how he was getting results with his saggers. He had a spare kiln and his men carried the green saggers into this kiln until it was full and then fired it. He fired this kiln two cones higher than he expected to go when using them. He told me further, "I dare not tell anybody, any manufacturer, how low my sagger cost is because they would think it was not true."

A MEMBER: How long can you use your grog?

A. V. BLEININGER: I do not know. That is a difficult question to answer. It is a question of whether bisque or glost grog is used. Glost

sagger grog becomes bad in a short time. Frequently, when you take a grain of glost grog and examine it, you see that it contains hundreds of small drops of glaze. These are minute, but still they are there, and they are effective. Therefore, I really could not answer this question as to how long the grog can be used, because I do not know. Broken saggers of a superior refractory quality could be used for quite a long time, because they would not be suffering in their refractoriness in use. But the lower the refractory quality of the sagger as a whole, the shorter must necessarily be the life of the grog. Of course, as sagger losses have been, we did not worry about them because we are replacing the clay so often and in such large quantities that it remains freshened up in very good shape.

A. A. WELLS: The potter wants a sagger having a long life. Sometimes that is not as unadulterated an advantage as it might seem. We have found saggers that after repeated firing were still good, sound saggers; that is, good enough to go into the kiln, but they have reduced so much that they are actually a cost to the plant.

Here in the past year we noticed a peculiar thing in one of our plants. They had a higher sagger cost than any other. Nevertheless, the lower percentage of kiln dirt that we got more than balanced the added cost. They were apparently tight saggers, so tight they cut short life, but no kiln dirt. I think that is a point that should be considered in merely long life saggers.

T. A. SHEGOG: I should like to ask Mr. Bleininger about the weathering of clays. I remember many years ago at a meeting of the English Ceramic Society we discussed that question at great length. There was a very general agreement that the shorter life the sagger had at that time compared with what it had had some years before and although made of precisely the same clays was due to this lack of weathering.

At that time the clay was mined one day and made into saggers the next. The trouble became so acute that many plants experienced extreme difficulty in keeping up their stock of saggers. I approve of the wet pan treatment for sagger clays. Did Mr. Bleininger mean that the sagger mix does not derive a benefit from the wet pan treatment? I do not for a moment suggest that the wet pan treatment is a substitute for the weathering, but as a mixing agent I think the wet pan has no equal.

In many of the whiteware potteries, the sagger is turned over as soon as it becomes dry enough. It is turned over on the board and dried upside down. The main idea is to prevent the dishing which we sometimes see in saggers after they have been fired a few times. The inversion of the sagger in drying it in that position curves the bottom and makes it less liable to dish in subsequent firing in the kilns.

In regard to quick cooling, a case came under my notice a couple of months ago where owing to one of a set of glost kilns being continually

under repair they were cut down in their glost capacity from four kilns to three, and out of those three kilns they got nine kilns of ware. That involved cooling of the most drastic order. The fan was used as soon as the door was broken down. I made the suggestion there, but to my surprise it was not acted upon. In that town they have a local fire department which does not get much work and I thought they could utilize this department to turn their hose into the kilns to quicken it in that way so as to become cool much sooner.

A. V. BLEININGER: The point which I made in regard to the use of wet pan was this, that in the plant using it, the sagger cost per kiln or per thousand cubic feet of glost kiln space is somewhat higher than it is in the other plants using the old process.

I think Mr. Shegog is correct when he says that the wet pan is an ideal mixing machine, but it does not do away with the necessity of the preliminary sprinkling treatment. I do not mean by this an ordinary wetting, but a systematic sprinkling of the clay from time to time. In using the wet pan the men got the idea that it offered such a thorough preparation that the preliminary wettings were not so necessary.

C. C. ENGLE: I have had a good deal of work along clay technology from the agricultural standpoint. I believe ceramists will have to turn more to the microscope just as our colleagues, the soil people, have had to do.

I am sorry that I do not have some of their figures with me. Some of you are familiar with some of the work that has been done but if you were to know the figures which give the area, for instance, of an ounce of clay particles, the area that they cover, it would amaze you. I think that is tied up with the weathering.

Speaking of weathering, my understanding of your point of view is that you get a thorough saturation. I am inclined to think that the clay miners cannot do that for you, unless we put in concrete bins or something of that sort, because if we pile it out as we do at our mines—not as much as we would like although we pile out a great deal of clay to be weathered—in the summer that clay would be extremely dry sometimes. It is practically bone dry when we ship it. It may have benefited by that weathering but to accomplish your purpose it seems as though you would have to begin right at the same point as though the clay were moist. I do not see how we can accomplish that for you.

I think that you want to turn more and more to the microscope.

K. M. SMITH: Dr. Mellor of England, while visiting our plant suggested that we add tannic acid to the sagger mix. He makes tannic acid by soaking straw in water and using that water. He also suggested that we soak the grog, keep it in the bin covered with water and get it thoroughly soaked, and when we are putting up the sagger, shovel that

wet grog out into the sagger soak. He says it causes a better bond between the clay and the grog.

C. F. GEIGER: Saggers are about the poorest quality of ceramic product made in this country. I think there are two things wrong with saggers. In the first place, the shape is very bad. We can take a hand-made ring that would correspond to the outside ring of a sagger and make it quite accurately and likewise make a bottom from a solid piece of clay. If we put that through the regular drying and firing procedure we shall find that in most cases the rings will shrink more than the solid body. In one case we had a total shrinkage of 10%. In this case, the solid bottom was about $6^1/_2\%$. Then we try to stick those two bodies together and the result is, of course, that we set up some very severe strains, and those, of course, shorten the life of the sagger. I think that undoubtedly is one difficulty.

Another is in the formation of the sagger. Most of us are using sagger presses and we throw a wad of clay on the bottom of the box and the plunger comes down and spreads the clay. It is supposed to force it up in around but we certainly do not get uniform pressure or density throughout the mix. We spread it and do not put it under compression as we do when we form fire brick.

C. D. FRAUNFELTER: I have had the same point in mind, except that I believe in employing mechanical pressure on the outside bottom of a sagger made upside down, the platen of the press covering the entire bottom surface. I have always kept a Patterson Steam Press for this purpose, believing that we had a more uniform density of side walls, corners and bottom than by any other method of manufacturing.

C. F. GEIGER: My suggestion on the first point was that we might try separate slabs for the bottom and rings for the side. Some of us can do that, although we think we cannot. We have let the man in the shop tell us we cannot do it. Use a heavier bottom slab and loose ring.

R. V. MILLER: We are using a wet pan process. We do not soak the clay as Mr. Bleininger has explained, but pass it through the wet pan and age it for two days or more when possible. When this clay is not aged it does not work as well for the sagger maker. They can always notice that difference. As to the life of the saggers, I cannot give you any figures as we changed our mix when we installed the wet pan.

R. W. HEMPHILL: Somebody raised the point about the use of humidity driers for saggers. We tried it out and it works all right. We do not do it right along but I know the idea is good. I think the reason saggers stand up when fired at higher temperatures is the mere fact that they are more refractory. They cannot help but stand up better.

K. M. SMITH: We have found that the life of our rings is not as long as the life of the saggers. I would like to have that accounted for.

F. H. RIDDLE: Is that because they lack the reinforcement the bottom would give?

K. M. SMITH: They get practically the same as the sides do.

F. H. RIDDLE: We tried two or three times making the walls of a different mixture. Of course, where there are different shrinkages the wall will be torn off. That is one thing to be careful about.

DISCUSSION ON "DUNTING AND SHIVERING OF PACIFIC COAST CLAYS"

By RUFUS B. KEELER

It seems that everyone of us at one time or another has had to deal with the question of dunting, and it is rather difficult to explain the real reasons for this phenomena.

I have in mind a certain terra cotta cornice, which was made many years ago, and shipped to the state of Utah. This job developed dunting shortly after it was in place, and after two years' time I inspected it and found that fragments of the cornice were continually breaking off and dropping onto the ground. It was apparent that dunting had been primarily to blame, and that the freezing and thawing action of the weather had completed the damage. I inspected some of the same pieces, retained as extras on this particular job, and which had remained on the Pacific Coast. These pieces showed very fine dunting cracks, but bore no other evidence of separation, such as did the material on the job.

Since that time dunting and shivering seem to have occurred periodically at various times in various factories; in many cases shivering the glaze from the surface of the ware on all the rounded moldings.

In the manufacture of domestic stoneware on the Pacific Coast this same shivering has been in evidence even in round jars. The shivering cracks occurred either as long straight vertical cracks, or else spiral cracks, starting from the bottom of the jar and running to the top.

In the manufacture of chemical stoneware I have seen perfectly good ware come from the kilns, and after exposure overnight, or perhaps for a few days, the same dunting appeared as in the domestic stoneware bodies. The cracks would manifest themselves either by sound or might be seen by bathing the surface of the body with water.

Sanitary ware made from imported china and ball clay together with customary flint and feldspar additions has also dunted, the same being delayed sometimes for many days. In fact, it would not be unusual to hear the cracking sound at night in the warehouse from all sections of the stock pile. We often find that our so-called safe and perfect bodies periodically develop spells of dunting.

The first place we look for the correction of this difficulty is in the cooling of our kilns, believing that the quick cooling would induce the cracking of the ware. It is usually found, however, that the ware cracks just as badly, if not worse, when the kilns are completely mudded up after firing, and allowed to cool very slowly.

In the second place, we usually look for an excess of free silica in the body, believing that a formation of tridymite is responsible during the cooling period. This belief, however, is offset by the fact that the addition of ordinary clean quartz sand to such a body often minimizes the dunting, whereas, theoretically speaking, it should immediately cause increased dunting.

Lastly we look to our body, not as to the analysis of a single sample, but as to the general character of a carload of clay, making samples of the car in general. Stiff mud pressed trials have shown that very few of the average fire clays on the Pacific Coast really fire hard and compact at cone 8 or 9 and remain so for any length of time. In fact, pieces which have a fairly good ring after coming from the kiln seem to lose this tightness and become chalky after several days' exposure to the air, and very often small dunting cracks are seen upon close examination.

It is apparent, therefore, that a great deal of knowledge is yet to be gained regarding the dunting of various clays which we use commercially on the Pacific Coast. I do not have reference to the very small stiff mud pieces that are usually made from these clays, but to the larger and flatter sections which range from a foot square upward, and are usually made in thickness varying from $^3/_4$" to $1^1/_2$".

In conclusion I will say that the clays themselves seem to be largely responsible for their actions after firing and it has been my experience that very few clays, or very few mixtures of clays may be relied upon. It is my sincere hope that some of our members will contribute their experiences to this discussion.

CALIFORNIA CLAY PRODUCTS CO.
SOUTHGATE, CALIF.

DISCUSSION, ON "BALLING IN CAST WARE"[1]

E. H. FRITZ: Do you have any trouble in filling the mold this way and casting it and getting this section right here?

W. K. MCAFEE: That section could not appear in a finished part of the piece, of course; that is, there would have to be a little finishing that would probably show. If that was on the front of the piece of sanitary ware where it is apparent something else would have to be done. Fortu-

[1] W. K. McAfee, "Balling in Cast Ware," *Jour. Amer. Ceram. Soc.*, **8** [7], 430–1 (1925).

nately it comes on the bottom of the tank where it is not easily seen. It does show slightly.

R. W. HEMPHILL: We tried to cast a piece about one and one-half inches thick. That is pretty thick for our slip. The piece always split up on the inside and cracked. We could not do it at all. I know that the body was not right to cast that heavy, but at the same time the same laws ought to apply to it.

C. C. TREISCHEL: What effect will the condition of the slip have on balling?

G. T. MORSE: In some cases where the slip is a little thick, in casting heavy pieces the outside has a skin on it. It will not cast in the center, especially if there is high balling.

C. C. TREISCHEL: Will that cause balling or hollow centers?

G. T. MORSE: It will not cast in the center at all if it is left in the mold too long. If it should be cast up in 12 or 14 hours and it is left double that time hoping it will cast, it will be worse.

G. M. MARTIN: Anybody who has cast has had that experience. We pour the tanks opposite from the way that was poured (that is, from the top of the tank). We have a ventilating funnel in one corner and pour from the other. As long as we can keep the slip in condition and keep the flow steady, we have no trouble with balling, but if the slip runs heavy, as it does occasionally when we get off in the clays, we usually have trouble with balling.

A. FOLTZ: If fifteen casters work on a certain floor, there will be no one of those fellows who will have at least 75% more balls than anyone else. Some of them never have any. And the other fellows may have one out of one hundred. You will have some fellow who will have twenty in a week. There must be a great difference in how the work is done, because if the slip is prone to "ball," it could not be confined to any one or two men in the shop.

H. GOODWIN: On that point, we had two men making the same work, using the same molds and the same slip. One man did not get a single piece cracked the whole week and the other got 18 pieces in one day. That shows the difference between the work of two men.

W. L. SAMPLE: To answer to Mr. Foltz's question: Balling, as has been shown, is the direct result of congestion, in a narrow part of the mold, shutting off the supply of slip to a wider section which has not cast solid, and which cannot be drained. The congestion in the narrow part is caused by the section casting solid. A careful workman will see that the mold at the narrow section is sufficiently wet that it will not cast quickly, thus allowing free passage of the slip to the wider section till it is cast solid.

W. J. J. BOWMAN: If the slip is working right and only balling in

certain pieces it is due to the method of feeding the slip to the piece. If it is due to the body, then the body is shutting off and not feeding long enough. The body change, to stop balling, is to give it a longer feed.

C. C. TREISCHEL: Would there be a change in the body?

W. J. J. BOWMAN: Yes, change the body if the slip stops feeding too early.

C. C. TREISCHEL: In order that this will go down into the records completely I am going to sum up the general impression of this discussion. In the first place, it would seem as though the condition of the slip has something to do with balling; second, that mechanical difficulties in the design of the mold will cause balling; third, that balling can be sometimes attributed to slackness possibly on the part of the workmen; and fourth, to a condition of body structure. I differentiate body structure from the condition of slip because of Mr. Bowman's remarks.

DISCUSSION ON "QUANTITATIVE DETERMINATIONS OF THE DEVELOPMENT OF MULLITE IN FIRED CLAYS BY AN X-RAY METHOD"[1]

F. H. RIDDLE: The different amounts of mullite developed in clays makes me wonder whether this is not the reason that some of our clays have given better bodies than others. Shall we not discover that this is one of the reasons?

R. A. HEINDL: Did you find that fluxes have any effect on the formation of mullite?

L. NAVIAS: The temperature of cone 10 was just high enough to cause vitrification of the feldspar and there was not much contact reaction between the larger grains of clay and the feldspar. I doubt if there was very much influence from that point.

We find in some of the porcelains, for instance, that the mullite development will consist of crystals contained in a clay particle and not in contact. For instance, we will get aggregates of mullite grouped in various forms depending upon the nature of the clay particle and quite often a quartz particle may lay on one side of it and possibly some feldspar on the other, but the effect of these particles at that temperature is hardly sufficient to affect the crystallization in the clay.

K. M. SMITH: According to the chart, is it the clay that is relatively high in alumina that develops mullite most extensively? Would you recommend using bauxite clay or introducing bauxite clay into a body to increase this mullite crystallization and increase the strength of the body?

L. NAVIAS: Your question brings up a number of considerations which

[1] Louis Navias, *Jour. Amer. Ceram. Soc.*, **8** [5], 296 (1925).

we touch on but cannot answer directly. I doubt whether the addition of an aluminous body as such and fired to low temperatures will give us anything more than inclusion of the bauxite or alumina. It would be a matter of filling up space in the body. Now the temperatures which we have to reach in order to get fusion at the surface and intimate contact with resulting crystallization I feel are higher than we are usually accustomed to. However, the subject of aluminous clays certainly ought to be studied from this viewpoint and also from the theoretical viewpoint to determine the correlation.

W. L. SAMPLE: Is there any significance in the fact that the higher silica content in the clay the less mullite is developed? Has this any detrimental effect toward the development of mullite?

L. NAVIAS: So far as I can determine from the calculated values of the maximum quantity of mullite to be obtained we actually obtained just that quantity on each clay at the temperature at which we worked; further that the presence of silica merely acted as a diluent in the body. Naturally we cannot expect any more mullite than is allowed by the ratio of alumina present. The presence of a great excess of silica, colloidal silica, finely divided silica, and also the addition of flint in the body would have the effect of increasing the viscosity of the body at that temperature, and as it was increased, the development of the mullite would at least be arrested to the extent that the crystals would be smaller and possibly have difficulty in asserting themselves in the body.

R. A. HORNING: Was there any feldspar in the mixture?

L. NAVIAS: Feldspar was used as a matrix for the second series. The first series of films showed the clay alone, the fired clay against the mullite, but their density was so great that we were not able to make any comparisons and for that reason we had to dilute the clay in order to make the comparisons.

R. A. HORNING: Did that alumina in the analysis include the alumina in the feldspar too?

L. NAVIAS: No, the figures shown were the analyses of the clays.

J. W. GREIG: In reference to the standards used to compare with the fired clays and feldspars, how were those standards actually determined? How did you happen to know the percentage of mullite in the standards?

L. NAVIAS: The standards were made by taking definite proportions by weight of the mullite and feldspar, mixing thoroughly and firing in the form of cones. These were ground and later examined under the microscope. From that work and from previous work we know that the mullite is not appreciably dissolved. So far as we could determine there was as much mullite as we had put in.

J. W. GREIG: How long must you have the temperature to bring about the fusion of the feldspar?

L. NAVIAS: The fusion of the feldspar takes place at about cone 10.

J. W. GREIG: How long a time is it held there?

L. NAVIAS: It was fired in the regular periodic kiln. The entire firing takes about three days. The maximum temperature is held only for a few hours.

J. W. GREIG: About how many hours would the temperature above the fusion of the feldspar occur?

L. NAVIAS: Not more than four or five hours.

A NEW ELECTRICAL RECORDER[1]

BY THOMAS R. HARRISON[2]

ABSTRACT

The construction and operation of a new electrical recorder is described.

During the past five years the Brown Instrument Company of Philadelphia, Pa., has developed a recording and automatic signalling and controlling instrument of the deflecting D'Arsonval galvanometer type for use with thermocouples, radiation pyrometers, resistance thermometers, thermal conductivity gas analysis apparatus and various other devices mentioned later. When used with gas analysis apparatus the ammeter, adjusting rheostat and slide wire for zero adjustment are mounted inside of the recorder case.

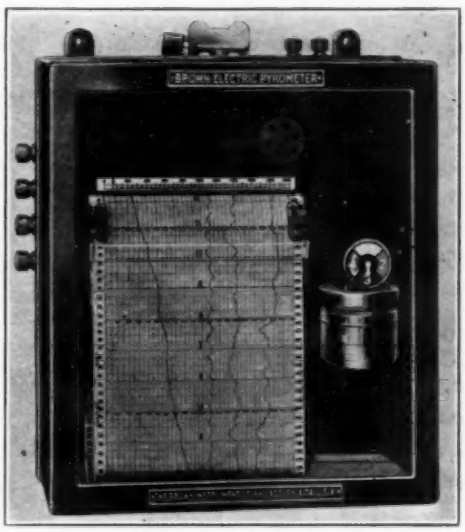

FIG. 1.—New Brown Recording Pyrometer.

Figure 1 shows the external view of the instrument, the case of which is 15 inches high, 14 inches wide, and 9 inches deep. The chart is 7 inches wide and when traveling at the standard rate of one inch per hour, the height of the instrument permits the record for the past 9 hours to be visible. Various other chart speeds are obtainable ranging from 1/4 inch to 6 inches per hour; interchanging 2 gears gives a paper speed of 4 inches per hour.

The instrument makes either a single chart or by use of an automatic

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[1] Recd. Aug., 1925.

[2] Director of Research, Brown Instrument Co., Philadelphia, Pa.

switch it makes records from two, three, four or six thermocouples, distinguished by the different colors and color combinations in which the records are printed. A duplex instrument, which has two galvanometers, and two charts printed on one strip of paper occupies a somewhat wider case. By using a duplex instrument with selective switches a 12-point recorder may be obtained.

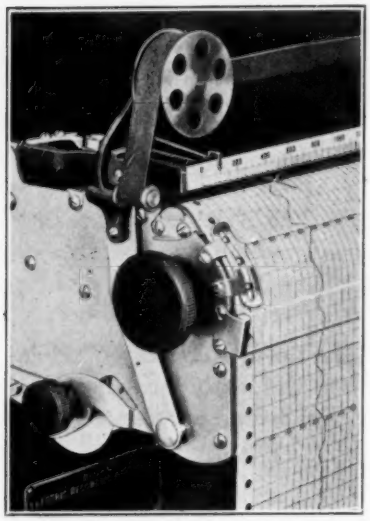

FIG. 2.—Marking ribbon moved back to make record visible.

The chart passes over a rectilinear knife-edge which is at right angles to the direction of travel of the paper and directly above the paper feed roll. A carbon or inked ribbon is stretched across the paper directly above this knife edge. The galvanometer pointer swings above the ribbon and when the depressor bar drops it strikes the pointer causing a dot on the chart.

With one depression each 30 seconds the dots in each record are close enough together to render an almost continuous line. The marking ribbon of the single and duplex recorder, after each mark on the chart, is moved back disclosing the last impression so that the record is clearly visible immediately after it is produced (Fig. 2).

An automatic selective switch is used with the multiple recorders which consists of gold contacts mounted on bakelite and immersed in oil. The oil keeps the contacts perfectly clean and in good electrical condition at all times. The switch is provided with a dial marked with the various numbers of the thermocouples and showing the color or color combination corresponding to each as used on the record chart. A hand rotates on the dial showing which thermocouple is connected to the recorder at any instant.

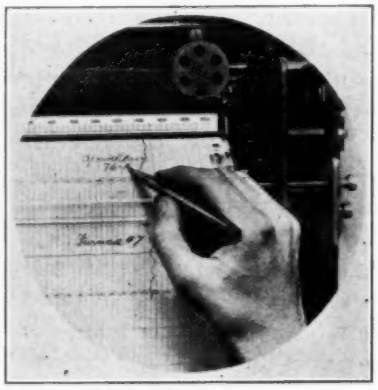

FIG. 3.—Support for writing notes on chart.

A platen placed directly below the driving roll is convenient for making notes on the record chart with pen or pencil (Fig. 3).

For use with thermocouples the recorder is provided with a bimetallic spring cold junction compensator, and a bimetallic index which indicates the correct "zero" or open circuit reading for the compensated instrument.

Where alternating current is available, the recorder is operated by a 4-watt synchronous clock motor, thus eliminating the winding of clocks, use of governors, etc., for securing accurate time keeping qualities.

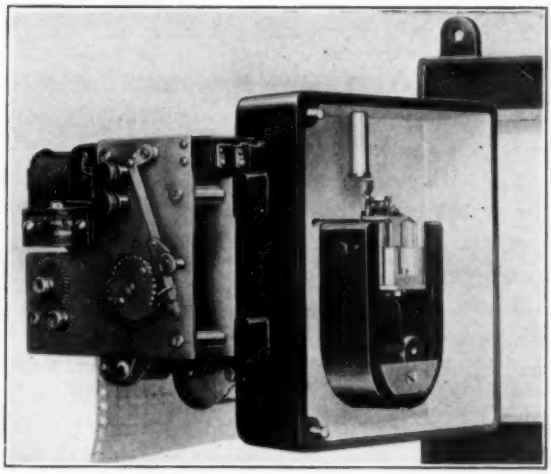

FIG. 4.—Enclosed galvanometer and chart driving mechanism with speed change gears.

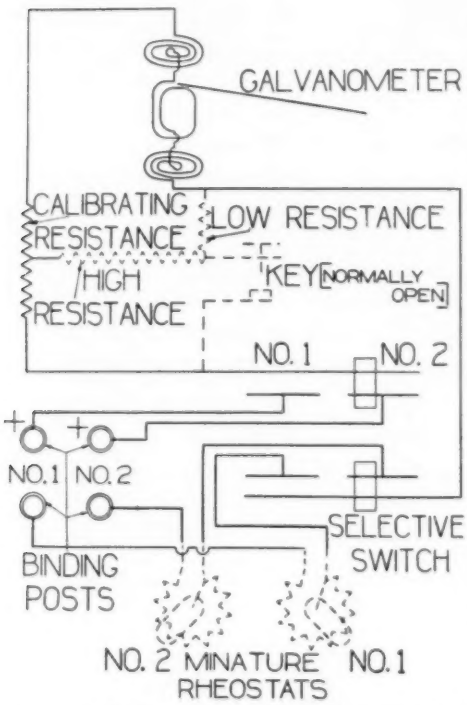

FIG. 5.—Wiring diagram of two-point recording "heatmeter."

These recorders can be supplied equipped with the heatmeter circuit[1] and miniature rheostats equal in number to the switch points on the selective switch. One rheostat is connected in series with each thermocouple circuit. Pressing the push button shows whether each rheostat is properly adjusted to calibrate the instrument for inequalities in circuit resistance caused by various lengths of lead wires, etc. No change in recorder reading when the button is pressed indicates a correct rheostat adjustment, independent of contact resistance, etc. Very infrequent readjustments of the rheostats are usually sufficient but on account of the ease of making

[1] Harrison and Foote, *Jour. A. I. E. E.*, **2**, 20 (1920).

the test it is never necessary to make assumptions as to the correctness of the circuit resistance.

On account of the principle of magnification of errors for making corrections, an adjustment which is apparently good to 5° will actually be good to 1°, and so on in proportion.

The wiring diagram of a 2-point recording heatmeter is shown in Fig. 5, the parts drawn in solid lines being those common to all recorders of this type and the dotted parts being the additional parts involved in the heatmeter circuit.

Where the rheostat contacts may be affected by corrosive gases in the atmosphere they can be supplied in cases suitable for filling with oil which may be mounted within the recorder case or outside on a panel.

A controlling or signalling attachment has been developed for this instrument which is capable of handling larger currents than usual, eliminating the necessity of relays in many cases. The contacts for this attachment are operated by power derived from the driving motor. When the galvanometer needle is depressed the appropriate one of several pivoted arms is swung out of a position of rest. A cam then allows the switch to move forward until stopped by the displaced arm, thus fixing the position of the switch in accordance with the length of the chosen lever. In different positions the switch makes different connections. The pivoted arms are of various lengths to select the different switch positions. Different arms are thrown out by the pointer depressing against different spring extensions spaced adjacently to correspond to the usual high neutral and low positions. Even more pivoted arms and switch contacts can be supplied where desired.

In addition to use as pyrometer recorder, gas analysis recorder, etc., the instrument may be provided with suitable sensitive elements and be used as recording voltmeter, ammeter, tachometer when attached to suitable direct current generator and for a number of special applications.

ACTIVITIES OF THE SOCIETY

NEW MEMBERS RECEIVED FROM AUGUST 15 TO SEPTEMBER 15

PERSONAL

Milton K. Akers, Hobart Mfg. Co., Troy, Ohio. Development Engineer.

Walter Emery, Pottery Teacher, Pottery Laboratory, Stoke-on-Trent, England.

Meyer L. Freed, 26 Cortlandt St., New York City. Chemist for Henry A. Golwynne.

Richard-Ginori, Società Ceramica, Colonnata, Florence, Italy. Insulators and Artistic Porcelain.

Richard-Ginori, Società Ceramica, Casella postale 1261, Milan, Italy. Earthenware and Porcelain.

O. E. Mathiasen, Ceramist, New Jersey Terra Cotta Co., Perth Amboy, N. J.

I. F. Ponomareff, Dean of Chemistry, Director of Sibernian Ceramic Station, Institute of Technology, Tomsk, Siberia.

William C. Snowdon, Technical Assistant, Osram, G. E. C. Glass Works, N. Wembley, Middlesex, England.

Frederick S. Thompson, Glass Technology Department, National Lamp Works of G. E. Co., Nela Park, Cleveland, Ohio.

CORPORATIONS

Booth Brick, New Toronto, Ontario. F. W. Booth.

The U. G. I. Contracting Co., 1401 Arch St., Philadelphia, Pa. D. J. Collins, Vice-President.

Membership Workers' Record

	Personal	Corporation
D. H. Fuller	1	
Charles F. Geiger		1
R. K. Hursh	1	
Percival Marson	1	
Office	6	1
	9	2

PERSONAL NOTES OF MEMBERS

A. L. Donnenwirth has left the Westinghouse High Voltage Insulator Co., Derry, Pa., and is located at Flint, Mich., with the A.-C. Spark Plug Co.

E. M. Durant has moved from Los Angeles, Calif., to 401 Oaklawn, Pasadena, Calif.

James Gould has become affiliated with the Buckeye Porcelain Enameling Co. Cincinnati, Ohio. Mr. Gould formerly was Superintendent of the Scranton Enameling Co.

T. A. Klinefelter of Gladding, McBean & Co., has moved from Lincoln, Calif., to 351 W. Wilson Ave., Glendale, Calif.

Erwin F. Lowry has resigned as Research Physicist for the Armstrong Cork Co., Lancaster, Pa., and is associated with the Westinghouse Research Laboratory, East Pittsburgh, Pa.

Emerson P. Poste has accepted a position as superintendent of enamels with the Chattanooga Stamping and Enameling Company and assumed his new duties with that Company on September 15. Mr. Poste has served as director of laboratories of the Elyria division of the Pfaudler Company since June, 1925 and has been associated with various phases of this Company since 1912. Mr. Poste has been a member of the SOCIETY since 1912 and has been active in the Enamel Division work of which he was chairman for two years. He also served as chairman of the Northern Ohio Section for two years.

Solon Shedd, Professor of Geology and Head of the Department of Geology, has left Pullman, Wash., and has become associated with Stanford University.

Edward J. Vachuska, who last year was Assistant in the Department of Ceramics at Rutgers College, is situated with the Bureau of Mines Ceramic Experiment Station, Columbus, Ohio.

RESOLUTION BY BOARD OF TRUSTEES

Employment of Technical Men in Public Positions

The Board of Trustees of the AMERICAN CERAMIC SOCIETY presents the following resolutions:

WHEREAS: It has frequently come to attention that public positions and offices requiring engineering or technical training, skill and experience are often filled with persons wholly lacking in such qualifications; and

WHEREAS: Such practice is inimical to and not in the interest of public policy and well being, the protection of life, health and property;

Therefore, be it Resolved: That AMERICAN CERAMIC SOCIETY urgently recommends that public positions and offices requiring engineering or technical training, skill and experience be filled only with technically qualified persons, and

Be it Further Resolved: That all state and local engineering and technical societies be urged to coöperate with the public to obtain such proper officers.

PROPOSED AMENDMENT TO CONSTITUTION

All papers, discussions and other writings which may be of interest or value to the SOCIETY if published, and which have been presented to a general session of the SOCIETY, shall become the property of the SOCIETY and their publication and other disposition shall be in the hands of the Committee on Publications.

No paper, discussion or other writing which may be of interest or value to the SOCIETY if published which has been presented before a division or local section shall be offered for publication elsewhere until the Committee on Publications shall have had the option of accepting the same for use in the *Journal of the American Ceramic Society.*

No committee reports prepared by a committee of the SOCIETY or of a Division or Local Section shall be offered for publication elsewhere until the Committee on Publications shall have had the option of accepting the same for use in the *Journal of the American Ceramic Society.*

L. E. BARRINGER
Chairman, Committee on Rules

JOINT COMMITTEE ON FOUNDRY REFRACTORIES

This meeting, as scheduled, was held on September 14th, at Mellon Institute, Pittsburgh, and the following were in attendance:

Mr. C. N. Ring, representing the Electrical Steel Founders' Research Group and the American Foundrymen's Assn.; Mr. J. L. Cummings, The S. Obermayer Co., Chicago, representing the American Foundrymen's Assn.; Mr. G. A. Bole, Bureau of Mines, representing the Bureau of Mines; Mr. W. J. Corbett, Secy. Steel Founders' Society of America, representing the Steel Founders' Society of America; Mr. H. R. Colwell, Division of Simplified Practice, Department of Commerce, representing the Division of Simplified Practice; Mr. J. T. MacKenzie, metallurgist, American Cast Iron Pipe Co., representing the American Electro-Chemical Society; Mr. M. C. Booze, representing American Refractories Institute; Mr. L. C. Hewitt, representing Committee on Coöperation, Refractories Division, AMERICAN CERAMIC SOCIETY.

At this meeting the writer was elected permanent chairman of the group and Mr. J. L. Cummings, secretary. Sub-committee chairmen were appointed as follows:

Simplification of Standardization of Shapes—Mr. W. J. Corbett.

Tests and Specifications—Mr. M. C. Booze.

Service Conditions—Mr. C. N. Ring.

Further sub-committees will be appointed under the direction of Mr. Ring relative to determining service conditions in various branches of the industry, such as the iron foundries, steel foundries, non-ferrous, etc. The complete personnel of these various committees has not been fully decided upon and the selection of these members will be left to the various sub-committee chairmen, the work to be eventually tied in through the Joint Committee and its Chairmen.

As will be ascertained from the above, it is hoped that this group will standardize refractory shapes for use in foundries, such as sleeves and nozzles, runner brick, cupola blocks, bung brick, etc., to make industrial survey of the conditions present as affecting refractory service, leading up to testing of such refractories as are used in the foundry industry, the entire work being correlated eventually into specifications covering refractories for foundry use.

OUR NEW HONORARY MEMBER

Twice the members of the AMERICAN CERAMIC SOCIETY have toured Canada visiting ceramic plants and being entertained by the Canadian ceramic manufacturers. On both of these occasions the members of this SOCIETY were impressed by the effective organization and collaboration of the ceramic interests in behalf of ceramic research and education. It was very evident that behind all of this there must be a directing and propelling force. This force was found to be in the Canadian National Clay Products Association.

The Canadian National Clay Products Association has on its roster and as its executive force and committeemen manufacturers of large financial investments. These men are members of technical societies and associations in the States; many of them are graduates of universities, several of the "school of hard knocks," but with ambition to study and achieve. It is no wonder that the Canadian National Clay Products Association has grown in strength and in productiveness, and it is not surprising to find this Association ready to a man, in not only personal support but in assessed financial support of a school of ceramics in the University of Toronto.

Canada now has two schools of ceramics, one at the University of Saskatchewan

and the other at Toronto University. Credit for these two schools is traceable to the Canadian Association.

As it is our aim to recognize the earnestness, the solidness, and the effectiveness of this Clay Products Association, the Board of Trustees at the last summer meeting voted to confer honorary membership on Mr. Gordon C. Keith, Secretary-Treasurer of the Canadian National Clay Products Association. Mr. Keith has continued since 1914 as Secretary of this Association, always alert to those enterprises which would advance the art and technology of ceramic manufacturing in Canada. Mr. Keith personifies the broad-mindedness and the progressiveness of the several members of this Association, and in electing him as honorary member of this SOCIETY it was intended that this should be in recognition of the quality of services rendered by the members of the Association, of which he is the continuing officer.

Gordon C. Keith was born in Smiths Falls, Ontario where he attended the Public School and Collegiate Institute, graduating in 1899. He attended Queen's University of Kingston, Ont., graduating with the degree of Bachelor of Science in Civil Engineering in 1907, Bachelor of Science in Mechanical Engineering in 1907 and Master of Science in Mechanical Engineering in 1911.

GORDON C. KEITH

He worked in the machinery department, cost and superintendent's offices of the Frost & Wood Co., Ltd., Smiths Falls, and the cost department of the Canadian Locomotive Works, Ltd., Kingston. He was editor of *Canadian Machinery, Power House and Canadian Foundryman*.

At present, in addition to being secretary-treasurer of the Canadian National Clay Products Association, he is editor and manager of *The Canadian Manufacturer* and secretary-treasurer and a director of The Commercial Press, Limited.

The Canadian National Clay Products Association was organized by the late Jonas Cornell of H. C. Baird & Son, tile manufacturers, in 1900. The first convention was held at London in 1901 when B. E. Bechtel of the Bechtel Brick & Tile Company was elected the first president.

Mr. Keith first became connected with the C.N.C.P.A. in February, 1912 when he read a paper on Power Problems of Clay Products Manufacturers at the tenth annual convention. He was then editor of *The Canadian Clayworker* which ceased publication during the war when the brick business was at a standstill. He was elected as member of the executive committee at that convention and in 1914 succeeded John R. Walsh as secretary-treasurer.

The C.N.C.P.A. has taken a great interest in education and the development of the industry in general, its latest achievement being the establishment of a course in Ceramics at the University of Toronto. The trustees in charge of the course are Ryland H. New, Chairman, Wm. Burgess, Harold F. Dingledine, and Gordon C. Keith.

In 1924 Mr. Keith was elected an honorary life member of the National Brick Manufacturers' Association, and an honorary life member of the Canadian Association of Stationary Engineers.

Mr. Keith is interested in flowers and is a member of the St. Clair Horticultural Society and a life member of the Ontario Gardeners' and Florists' Association. In summer he finds time to spend some time fishing at his summer home on the Rideau Lakes.

OUR 1926 ANNUAL MEETING

Next February during the week of the 8th this SOCIETY will be guests of the ceramic people of the South, particularly of Georgia. The Meeting will be in Hotel Biltmore, Atlanta, the first three and a half days and the excursion trip for plant and material deposits inspection will be in and about Macon, Gordon, McIntyre and Stevens Pottery, the clay deposits at Butler and at Augusta are well worth seeing. A week is too short a while to go all places where there are things of value to see. The meeting place and the inspection route were selected as giving a good idea of what the South has of interest to ceramists.

If time could be spared delegates are advised to stay over to visit the clay plants in Augusta and Butler, Ga., and also the clay, feldspar and other mineral deposits in North Carolina, Tennessee, Alabama, Mississippi, Kentucky and Florida.

The Southern states are rapidly being populated thus giving a growing home market. They have fine shipping facilities, a vast variety of ceramic materials and good labor. Industrially, the South is growing. To miss this Annual Meeting and the plant inspection trip through Macon and Wilkinson county one would be losing an opportunity of getting on a specially scheduled program and at two-thirds the usual cost, a first hand knowledge of this rapidly developing ceramic district. The Florida boom with its attending large building and equipping reaches the Southern factories and what is going on in Florida is duplicated in much of the South. Industrially and ceramically the Southern states are arriving with full steam on. You cannot afford to miss this opportunity to see the South in a clubby fashion through not only your own eyes but also the eyes of the other 800 ceramists who will be with you.

The seven Divisions already have their technical programs well in hand and papers are being pledged. Some of the papers are already in. The exhibit committee is ready with their announcements and even in advance they are being asked for space reservations. The local committee will have had their final meeting on September 24 but already they have pledged assurances of automobiles, special trains and entertainments. The local committee is all set and "rarin" to go and it is a very novel and instructive time they have planned. We are going to have a spirited, spiritual and inspiring time. Even General Lee on Stone Mountain is ahorse ready to show you his gallant troops in marching array. Your enlistment time is now. Write the Secretary of your Division about the papers you will read or wish to hear read.

Remember—Atlanta is not far distant from your place. Most of the 800 delegates will travel less than a day to reach Atlanta. You will then know why Georgia School of Technology, North Carolina State College and Tulane University have ceramic courses and laboratories, and why University of Louisiana and Missouri are planning for similar ceramic schools.

PITTSBURGH LOCAL SECTION MEETS OCTOBER 7[1]

The Pittsburgh Local Section of the AMERICAN CERAMIC SOCIETY is holding its first fall meeting at the Mellon Institute on Wednesday, October 7.

F. C. Binnall, Fuel Engineer of the Standard Sanitary Mfg. Co., is to give a talk on "Fuels" or some related subject.

This paper and discussion will be of interest to the enamel men in the vicinity of this section.

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[1] H. F. Robertson, Secy.

OBITUARY

Benjamin F. Carter

Word has been received of the death of Benjamin F. Carter of Bartonville, Illinois. Mr. Carter had been a member of the SOCIETY since 1917 and was affiliated with the Heavy Clay Products Division.

Carl D. Bossert

Carl D. Bossert of Columbus, Ohio, died very unexpectedly in Mexico, Mo., Saturday, Sept. 12, 1925. Mr. Bossert had been enjoying especially good health, but suffered a sudden attack of hay fever—his death resulting at a local hospital from heart failure.

Mr. Bossert, who was 41 years of age and a graduate of the department of Civil Engineering at Ohio State University, was closely identified with engineering work in Columbus for a number of years. For the past three years Mr. Bossert had been serving as a field engineer for Carl B. Harrop, Engineers and Constructors, and during that period has had charge of construction work in Michigan, California, New York, Ohio and, at the time of his death, in Missouri.

Besides being an excellent engineer, Mr. Bossert possessed a very amiable disposition, which enabled him to get along especially well in the handling of his chosen line of work.

Mr. Bossert's home was in Washingtonville, Ohio, near Salem, where he was buried Sept. 15, 1925.

A LIFETIME OF WORK IN CERAMICS

Dean Earle J. Babcock, University of North Dakota

BY THOMAS F. KANE[1]

The Ceramics work in the Northwest suffered its greatest loss in the death of Dean Earle J. Babcock[2] of the University of North Dakota, which occurred September 3, 1925.

Dean Babcock's administrative work covered the College of Engineering and the School of Mines. A large part of his attention personally as an investigator and research worker was on the clays and coal of North Dakota. The field of investigation and development was so vast that he had a rather large number of workers associated with him. All of these workers take pride in recognizing Dean Babcock as the directing head and the inspiration of all the work planned and carried out in these two great fields.

The clays in the state, he revealed, are almost inexhaustible in quantity, just as he showed by his investigation and the geological surveys that the coals of the state are measured in the billions of tons. In quality he showed through chemical analysis and laboratory manufacture that the clays are so pure as to lend themselves to manufacture into all of the commoner clay products and the finer wares without any admixture of other clays or substances.

Before the time of his death he had attained two of the great objects of his work with clays. He had demonstrated so that it is becoming known that the clays are one of the greatest and most valuable resources of our state. The other was that in his enthusiasm for the work he had organized about him a group of workers capable of carrying forward for a long time to come the experiments and development that could be forseen and projected.

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[1] President Univ. of N. Dak.

[2] For photograph of Dean Babcock see page 565, *This Bulletin*.

The laboratory work in Ceramics has been for fifteen years in charge of Miss Margaret K. Cable, a member of the AMERICAN CERAMIC SOCIETY, who commonly represented the University's clay work at the annual meetings of the SOCIETY.

Dean Babcock's death is a great loss to the interests of Ceramics, as it is to his university and to his state. His services, however, to Ceramics, as to his university and to the state, have been of such a nature as to project themselves far into the future to the permanent advantage of Ceramics.

Death of Carlton Geist

Word has just been received of the death on August 25 of Carlton Geist, President of the Geist Manufacturing Company of Atlantic City, N. J. Mr. Geist had been a member of the AMERICAN CERAMIC SOCIETY, as representative of his corporation, since 1924.

ART DIVISION QUESTION BOX

1. Is there a light firing clay which fires dense at cone 1, for example, and where may it be bought prepared for studio or school use?

DISCUSSION: The clay supplied by the Western Stoneware Co., Monmouth, Ill., fires to a light cream color and when glazed and fired to cone 1 to 2 is impervious.

The Sioux City Brick and Tile Co., Sioux City, Iowa have a good light firing clay which matures around cone 1 and is very plastic.

Many clays found around Chicago and the lower end of Lake Michigan fire buff and mature at cone 1 or even a little lower. However, they lack plasticity but the addition of 10% of bentonite overcomes this drawback.

The Indiana shale clay used by the Chicago Terra Cotta plants is buff firing and dense at cone 1.

2. Where do such schools as are listed below purchase their clays?

DISCUSSION: Alfred University, Alfred, N. Y. uses "Wescco" clay, sold by the Western Stoneware Co., Monmouth, Ill.

The Art Institute of Chicago gets most of its clay from the Mason City Brick & Tile Co., Mason City, Iowa. It fires red, comes dry and must be washed and prepared. Pottery made from this clay is waterproof when glazed and fired to cone 04.

The Cleveland School of Industrial Art uses Monmouth clay.

Lewis Institute, Chicago, uses a stoneware clay which is purchased and prepared in such large quantities that they are enabled to furnish prepared clay to other educational institutions at a reasonable price.

The Newcomb School of Art, New Orleans, obtains its clay from local sources.

The Museum School of Industrial Art, Philadelphia, uses Tuckahoe clay which it obtains from Wm. G. Moore and Co., Philadelphia.

Schenley High School, Pittsburgh, purchase their clay from the MacNichols Pottery Co., East Liverpool, Ohio. It comes plastic, fires light yellow and should be biscuited around cone 2.

The University of North Dakota is supplied by the Hebron Brick Co., Hebron, N. Dak., and the Dickinson Brick Co., Dickinson, N. Dak. These clays come dry, fire to a light cream color and are very plastic.

3. I have had difficulty since the war in securing flat potters' sponges. Where may they be obtained?

DISCUSSION: The best place to purchase such sponges is a wholesale drug concern. Myer Bros., St. Louis, carry a good grade of soft flat sponges.

4. What is the relative difference in the cost of purchasing glazes ready for use and making up one's own, provided one has the equipment?

DISCUSSION: If equipment for grinding is available it is considerably cheaper to make glazes rather than to buy them ready for use.

The following cost figures are approximate. They are based on current quotations on glaze materials in small quantities such as the individual or school potter would buy. In large quantities all materials, are of course, less expensive. These figures cover cost of materials only. Power and labor involved in grinding and preparation would be an additional expense varying according to conditions. Three typical glazes for cone 04–02 have been figured out in five colors as shown in table.

TABLE SHOWING COSTS PER POUND FOR MATERIALS ONLY

Typical raw glazes, cone 04–02	White or colorless	Blue	Green	Brown	Dull yellow	Bright yellow	Average list prices of similar glazes on the market
Matt glazes	0.10	0.12	0.11	0.11	0.11	0.20	$1.00 to 1.23 per lb.
Transparent lead glaze	.09	.12	.10	.10	.10	.18	$0.60 to 1.23 per lb.
Tin enamel (Majolica)	.13	.17	.14	.14	.14	.20	$0.75 to 1.50 per lb.

ARTHUR E. BAGGS

5. Is there any way that a porous biscuit body may be made waterproof except by glazing?

DISCUSSION: The suggestion has come in from several sources that a piece of biscuit ware may be rendered impervious by immersing it in a bath of hot paraffine or by coating it with a waterproof varnish or shellac. The piece may be decorated with dye, water color or oil paint prior to the treatment.

6. Where can a red firing clay be purchased in small lots, say 500 to 2000 lbs., washed, screened and plastic ready for use? How many would be interested in securing such a clay if some one could be found who could furnish it?

7. Wanted a brief description of a frit kiln suitable for small production such as needed in a school.

NOTES AND NEWS

THE FIRST HIGH SCHOOL CERAMIC COURSE

East Liverpool Has It

The ceramic manufacturers of East Liverpool, with federal and state aid, have established courses in ceramics to be taught in the East Liverpool High School. Kenneth M. Smith is the instructor. Behind him as co-workers and as an advisory board are C. C. Ashbaugh, J. M. Manor, Edwin L. Cawood, H. B. Barth, W. T. Blake, A. V. Bleininger, R. V. Miller and J. W. Hepplewhite.

The following two courses are to be opened October 1.

VOCATIONAL CERAMICS

Freshmen 1st Sem.	Hrs.	Credit	2nd Sem.	Hrs.	Credit
General Science	5	1/2	Phys. Geog.	5	1/2
English	5	1/2	English	5	1/2
Algebra	5	1/2	Algebra	5	1/2
Ceramics	15	5/8	Ceramics	15	5/8

Combined Laboratory and Shop Project

Sophomores 1st Sem.	Hrs.	Credit	2nd Sem.	Hrs.	Credit
English	5	1/2	English	5	1/2
Business and Acct.	5	1/2	Business and Acct.	5	1/2
Spec. Phys.	5	1/2	Spec. Chem.	5	1/2
Ceramics	15	5/8	Ceramics	15	5/8

Combined Laboratory and Shop Project

Juniors 1st Sem.	Hrs.	Credit	2nd Sem.	Hrs.	Credit
English	5	1/2	English	5	1/2
Pl. Geometry	5	1/2	Pl. Geometry	5	1/2
Commerce and Ind.	5	1/2	Industrial History	5	1/2
Ceramics	15	5/8	Ceramics	15	5/8

Combined Lab. and Shop Practice

Seniors 1st Sem.	Hrs.	Credit	2nd Sem.	Hrs.	Credit
Amer. History	5	1/2	Civics	5	1/2
Economics	5	1/2	Management	5	1/2
Mech. Drawing	5	1/2	Mech. Design	5	1/2
Ceramics	15	5/8	Ceramics	15	5/8

Combined Lab. and Shop Practice

COLLEGE PREPARATORY

Freshmen 1st Sem.	Hrs.	Credit	2nd Sem.	Hrs.	Credit
English	5	1/2	English	5	1/2
Algebra	5	1/2	Algebra	5	1/2
Language	5	1/2	Language	5	1/2
Gen. Science	5	1/2	Gen. Science	5	1/2

Sophomores 1st Sem.	Hrs.	Credit	2nd Sem.	Hrs.	Credit
English	5	1/2	English	5	1/2
Algebra	5	1/2	Pl. Geometry	5	1/2
Language	5	1/2	Language	5	1/2
Ancient and Med. Hist.	5	1/2	Ancient and Med. Hist.	5	1/2

Juniors 1st Sem.	Hrs.	Credit	2nd Sem.	Hrs.	Credit
English	5	1/2	English	5	1/2
Pl. Geometry	5	1/2	Solid Geom.	5	1/2
Physics	7	1/2	Physics	5	1/2
Ceramics	15	5/8	Ceramics	15	5/8

Combined Lab. and Shop Practice

Seniors 1st Sem.	Hrs.	Credit	2nd Sem.	Hrs.	Credit
Amer. History	5	1/2	Civics	5	1/2
Spec. Chem.	7	1/2	Economics	5	1/2
Mech. Drawing	5	1/2	Machine Design	5	1/2
Ceramics	15	5/8	Ceramics	15	5/8

Combined Lab. and Shop Practice

Eighth Grade Graduates Eligible.

Night Schools

Night schools for adults will begin about October 15 and run for twenty-four weeks. Messrs. Bleininger, Hepplewhite and Miller have conducted such night schools for two years in Newell, W. Va. These experts will instruct with Mr. Smith in the night school.

None of the work of this school will replace the apprentice system now operating in the several ceramic plants.

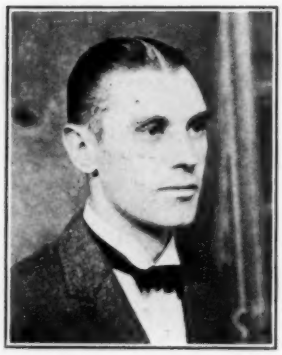
The board of education has ordered that the former chemistry and laboratory rooms of the Central School building, Fourth Street to be remodeled and used for this purpose. The floors of these rooms are to be cemented.

The raw material needed will be contributed by local potteries. This includes clays as well as brick. The manufacturers have also agreed to fire the ware made free of all cost to the pupils and the school board.

F. Q. Mason, color manufacturer and the Joseph Croxall Chemical Company are to present all colors, oxides and chemicals.

Machinery to be Installed

The machinery will be secured from the Patterson Foundry and Machine Company. It will consist of a motor-driven laboratory pebble mill, a motor-driven testing outfit, a motor-driven 3″ pan, a motor-driven friction jolley and pulldown, a nine and one-fourth ring for the same, a flat disk for throwing and two bench whirlers. Other materials of a smaller nature, which will include various tools, wiring, tanks, mortars and pestles and other accessories will send the total cost up to about $3000. Of this sum, the Patterson Foundry and Machine Company as its contribution "toward the educational work for the benefit of the children of the community" has donated the sum of $1000.



KENNETH M. SMITH

The local manufacturers have raised a sum of over $4000 to initiate the work of this school and plans are made to furnish the means locally and by state aid to permit the school to develop vocationally and in ceramic art to whatever the local industrial needs may dictate. A close collaboration with the Ohio State University ceramics department has been assured.

Being the first high school course in ceramics it is novel and without precedent. No one can foresee its future, but no effort will be spared to make of it all that it may be by money, enthusiasm and industrial support.

History of K. M. Smith

Kenneth M. Smith was raised in Tama, Iowa. He is 30 years of age, married and has two children. He was graduated from Iowa State College under Prof. Cox in 1924, and has for the past year served as ceramic engineer at the Cambridge Sanitary Manufacturing Company.

Those Served by the School

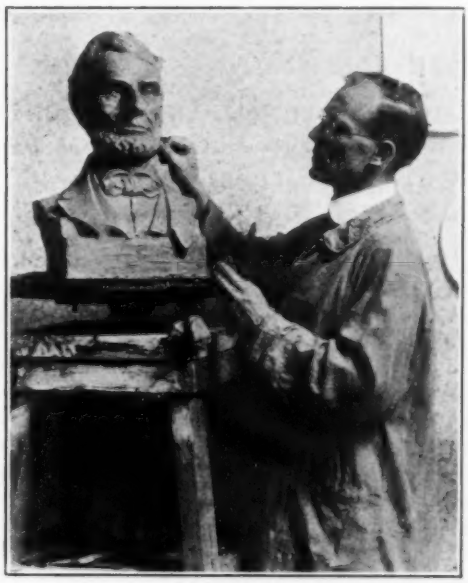
E. L. Heusch, vocation director of Ohio said to the East Liverpool advisory and financial committee with whom he met recently, "You are destined to see great things accomplished by reason of this departure. We have too long neglected the boy who for some reason or another quit school before securing a sufficient education with which to compete with his fellows in this material age in which we are living. Of 100 pupils who enter high school but 13 graduate. Of the 13, but 7 go to college. And of these 7 but 3 actually graduate from college. What of the 87 who never finished high school? They ultimately make up our workers and producers. Now in Ohio we have for some

time been out to help such as they. You are doing that very thing by this move in East Liverpool. We want as few handicapped persons in the world as possible. We should make it possible for all to partake of the inscription on a certain Ohio high school: 'That all youth may have a higher person life.' "

CERAMIC MODELING TAUGHT

By The Art League of Ellwood City

This league is practically in its infancy, only having been started one year ago last February through the Women's Civic Club. This Club held an art exhibit, renting paintings from various sources. In the collections were works of well-known artists, also a few bronzes. To these were added the works of local artists, paintings, pencil sketches and similar work done by students at school and a few architectural drawings executed by a couple of Pittsburgh Tech. students. The exhibit was held for one week. A fashion show was also put on and a talk by Mr. Taylor, head of the Painting and Decorating Department at Carnegie Tech., Pittsburgh, was given which proved most interesting.



B. L. WATKINS

It was a great surprise to everyone to find such a large number of people in Ellwood City who were interested in painting, so it was suggested by the Chairman of the Art Committee of the Women's Civic Club that a league be formed. Mrs. A. T. M. Thomas effected the organization and fostered it the first three months.

Matthew M. Riley was elected President, Louise Barton, first Vice-President, Phillis Charles, second Vice-President and Lewis Nickum, Secretary-Treasurer. The Vice-Presidents were supposed to act as heads of various committees as the different kinds of work came up. The organization was small, about fifteen members. Their aim was to improve themselves and finally to stimulate the interest of the community in Art. In May last year another exhibition took place of work done in the Pittsburgh public schools. The art director, Mr. Boudreau, lectured on the value of art in the public schools, a very fine and stimulating address. Several people expressed a wish to study clay modeling, so Miss Louise Barton, the fervent and energetic first Vice-President, at once set about organizing a class for this work in January.

The general manager of the Shelby National Tube Co., at Ellwood, James Dunn, and Matthew Riley of the same corporation, forthwith acted as sponsors and this class is so far maintained by them. The equipment was furnished by the Shelby Tube Co.

and the class is held in a well-lighted, airy basement of the Shelby Social Club. The class was primarily formed for school children and only a small fee is charged. One of the objects is to give the youngsters a useful occupation on Saturday afternoons, and to help to increase their powers of observation, love of form and beauty, an ability to appreciate all of the arts and to single out the very occasional person with special aptitude.

The services of Bertram L. Watkins of New Castle were obtained as instructor. He is the specialist in modeling for sanitary casting and has charge of the modeling and moldmaking departments at the Universal Sanitary Manufacturing Co.

Hailing from England his apprenticeship and training as modeler to the famous English pottery firm of Messrs. Josiah Wedgwood & Sons, Etruria, Stoke-on-Trent and Messrs. Howson & Sons, Sanitary Manufacturers, Hanley, also twleve years study in the Schools of Art gave him both the practical and artistic sides, and this has been appreciated by a most enthusiastic class. There are at present twelve juniors and six seniors. The class is held Saturday afternoons and the adult session on Wednesday evenings. Great progress has been made from quite simple objects to the more difficult casts and several adults have quite good examples of their work in the studies of flowers, fruit and heads.

It is intended to hold an exhibition of the work done in the fall.

VOCATIONAL AND APPRENTICESHIP SCHOOL AT ONONDAGA POTTERY[1]

At the present time the training work in this school is confined to young men in the Clay Shop. In the Clay Shop they have three grades:

First, the boys under seventeen, who by New York State Law are required to attend Continuation School four hours a week, are given Continuation School training within the factory, two hours a week being devoted to the simpler processes of forming ware and two hours to school work which embraces in an elementary way mathematics, English, civics and hygiene.

Second, boys over sixteen who have shown special aptitude are permitted to enter our Elementary Apprenticeship Training Course. To enter this a boy must sign a contract agreeing to remain in the employ of the company and to faithfully perform his work for a period of six months. Of course, this contract is not legally binding on the boy, but it is understood that if he does not keep his word he is given no further consideration by the Onondaga Pottery Company. In this contract the company agrees to give the boy two hours' training a week in the various processes in making ware. This training is given by skilled Clay Shop employees. In addition, the boys in the Elementary Apprentice Training Course, who are of Continuation School age, are given the same school work as the Continuation Shool boys receive. The State Educational authorities recognize our Elementary Apprentice Training Course equivalent to the Continuation School course. The boys in this course are graded and if their grades are satisfactory they receive a small cash reward each week; in addition they receive at the end of the six months a cash reward, depending upon the grade which they have averaged in their work in the course. After a boy has completed the first six months, and if he seems sufficiently promising, he is allowed to sign a similar contract for another six months. At the conclusion of the year's training, if his grade has been satisfactory, he receives a diploma as a graduate of the Clay Shop Elementary Apprentice Training School.

[1] A statement by R. H. Pass.

The boys in both the Continuation School classes and in the Elementary Apprentice Training Course are paid at their regular rate for the time spent in this work. They take it seriously and unquestionably profit from it. The general improvement in the class of boys in the Clay Shop has been very marked since we started this work.

In addition to the Elementary Work covered above, we have an Advanced Apprentice Training School in the Clay Shop, which is open to promising boys over eighteen. Preference is given the most successful graduates of the Elementary Course. This is equipped with regular production machinery and is segregated, being under an instructor who is a thoroughly good potter. In this school the boys put in full time, receiving just enough per week to cover living expenses. Here they go through the various processes of pottery making, spending most of the time in jiggering and the batting-out and finishing, which go with it. In addition to the Vocational Work, these boys receive every week a half day in special instruction—mathematics, civics, History of Potting, and, above, all, a series of lectures, given where the work is done, by the heads of the various departments, to explain the whole process of production and show the boys the important part their work plays in the long sequence of operations necessary to make the finished product. We find that it takes about fifteen months for a promising young man to do the work required in the Advanced Course. At the conclusion of the course, he receives a diploma stating he is a Journeyman Potter, and he receives also a prize in the form of an especially fine piece of pottery ware.

It has been very gratifying to notice the attitude of our older men toward the training work outlined above. Apparently they are glad to see steps taken to put a stop to the demoralization of their trade and to develop potters whose work is worthy of the traditions which the older men have created here.

NOTES FROM THE CERAMIC SCHOOLS

Before these notes are read ceramic schools will have opened their doors to students. Increased facilities in some instances and changes in instructional personnel in other give a new set up for the year. The schools belong to "the people" in general and to ceramic manufacturers in particular. The purpose of the following notes is to keep the schools and the instructors known.

R. J. Montgomery to University of Toronto

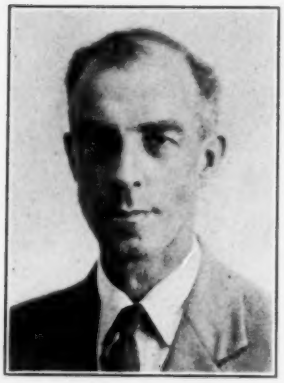
The Board of Governors of the University of Toronto has appointed R. J. Montgomery as Lecturer in the Department of Metallurgical Engineering, this to be a beginning of the Department of Ceramic Engineering to be established at that University. The work is being started at the request of the Canadian National Clay Products Association and considerable aid is being given by that organization in financing the course.

The ceramic work may be taken by fourth year engineering men as an elective. The course will consist of lectures, 3 hours a day, 3 days a week both first and second terms and 2 laboratory periods of 6 hours each every week during the second term.

Mr. Montgomery was graduated from the Ceramic Department of Ohio State University in 1911, and has held the following positions: Pittsburgh Plate Glass Co., Clay Research Laboratory, Creighton, Pa., 1911–15; in charge of the Refractories and High Temperature Division of H. Koppers Company's Laboratory, Mellon

R. J. MONTGOMERY

Institute, 1916–17; in charge of the manufacture of glass pots and furnace refractories as well as technical development work, Bausch and Lomb Optical Co., Rochester, N. Y., 1918–25. Mr. Montgomery worked there with the porcelain type of pot for the more corrosive glasses and the development of new optical and spectacle glasses not being made in the United States.



S. R. SCHOLES

Dr. Scholes at Ohio State University

Samuel Ray Scholes, who has been secured as lecturer on technology of glass to ceramic classes at Ohio State University for the year 1925–26, was born at Marquette, Wis., in 1884. He received his A.B. degree from Ripon College in 1905 and from 1905–08 was instructor in chemistry and physics at Wausau, Wis.; from 1908–11 he was laboratory instructor and Loomis Fellow in chemistry at Yale University and in 1911 received his Ph.D. degree from Yale.

Dr. Scholes was Fellow at Mellon Institute 1911–15; Chemist, H. C. Fry Glass Co., Rochester, Pa., 1915–20; Assistant Director, Mellon Institute, 1914–17; Superintendent, Utility Glass Works, Lonaconing, Md., 1920–21 and since 1921 has been Chemist for the Federal Glass Company, Columbus, Ohio.

J. L. CARRUTHERS

John L. Carruthers to Ohio State

John L. Carruthers was born in Colorado in 1895. He attended the secondary and high schools of Lafayette and Denver, Colo. and in 1921 received his B.S. degree in Ceramic Engineering from Ohio State University. Mr. Carruthers served in the Air Service, U. S. Army in 1918. Positions which he has held are as follows: Denver Sewer Pipe Co., summer, 1915; Plant engineer, Denver Terra Cotta Co., 1916–17; Construction engineer, Radium Co. of Colorado, summer, 1920; ceramic engineer, Denver Terra Cotta Co., 1921–22; construction and service engineer, Carl B. Harrop, 1922–25. Mr. Carruthers will be assistant professor in the department of ceramic engineering, Ohio State University for the year 1925.

A. I. ANDREWS

A. I. Andrews to Illinois

Dr. Andrews, who has been appointed Assistant in the Department of Ceramic Engineering, University of Illinois, was born in Baraboo, Wisconsin, 1895 and received his secondary education in the public and high schools at Oshkosh, Wis. He received his B.S. degree in 1920 and M.S. 1921 from the University of Wisconsin. While in residence at this University he acted as Assistant to Victor Lenher during the years 1920–22 and carried out

his research work under Dr. Lenher. In 1922 Dr. Andrews came to Ohio State University and assisted Dr. Evans, taking his major work under Dr. Withrow. In 1923 he was given the U. S. Bureau of Mines Fellowship at Ohio State University and in 1924 he received the degree of Doctor of Philosophy. Dr. Andrews for one year taught ceramics at Alfred University under the direction of Dr. Binns.

George Reed Shelton at North Carolina

George Reed Shelton, Assistant Professor of Ceramic Engineering at North Carolina State College, attended Maryville College and later Cornell, where he received his A.B. degree in 1912. He received his M.S. degree in Ceramic Chemistry at the University of Illinois, 1920 and his Ph.D. in Ceramic Chemistry from the same University in 1922. Dr. Shelton taught chemistry and physics at Mitchell High School, Mitchell, S. Dak., 1912–16; was Associate Professor of Chemistry at Maryville College, 1916–18; Research Assistant at the Engineering Experiment Station, University of Illinois, 1918–20; Corning Glass Works Fellow, University of Illinois, 1920–22. From 1922–25 he was chemist and petrographer at the University of Saskatchewan for the Engineering Institute of Canada.

GEORGE R. SHELTON

Dr. Shelton's research work for his Ph.D. was done on the viscosities of soda-lime-silica glasses at high temperatures and was carried out under the direction of E. W. Washburn. His work at the University of Saskatchewan was on the deterioration of Portland cement in alkaline soils. At North Carolina State College, Dr. Shelton will conduct classes on cements, lime, glasses, enamels and whiteware.

The new ceramics building at North Carolina State College which will contain classrooms, offices, laboratory, machine room and kiln room will not be completed in its equipment before January 1.

An enrollment of between 15 and 20 students consisting of freshmen, sophomores and juniors is indicated from the applications.

Preparations are being made for the second annual short course in clay working and ceramics to be held in January. This course will be devoted entirely to heavy clay products.

WALTER A. PREISCHE

Receives Appointment at Penn State

Walter A. Preische, a graduate of Alfred University as Bachelor of Science in Ceramic Engineering in 1924, is now a member of the faculty in the Ceramic Department of the School of Mines at Pennsylvania State College. Since graduation he held the position as production manager for the Shawmut Brick and Tile Company in their plants located at Shawmut, Penna. Later he became head of the Department of Mathematics of Oyster Bay High School, Oyster Bay, N. Y.

DEPARTMENT OF COMMERCE NOTES

The Concentration of Fluorspar Ores

An investigation to determine possible improvements in the milling of fluorspar is being conducted at Rolla, Mo., by the Bureau of Mines, Department of Commerce. A study has been made of tailings from concentrating mills in southern Illinois, and the material was subjected to experimental classification, and concentration with jigs and tables in order to determine its behavior. Sufficient progress has been made to indicate that considerable improvement in concentration and more economical recovery may be effected.

Firing Ceramic Wares with Oil

There is a wide demand for information on the efficiency of oil as a fuel for firing ceramic wares. A complete survey of all ceramic plants known to use fuel oil has been completed by the Bureau of Mines, Department of Commerce. The results show that oil is an excellent fuel for this purpose, because the fires can be kept clean, there is no trouble from smoke, and the temperature of firing can be closely regulated, all of which tends toward efficient burning with a resultant saving in fuel and labor.

Load Tests for Refractories

In the construction and operation of metallurgical and industrial furnaces, it is highly desirable to have accurate knowledge as to the load refractories will carry without deformation when heated to the intense temperatures developed in the furnace. Therefore, the ceramics experiment station of the Bureau of Mines, Department of Commerce, in coöperation with Ohio State University, has been conducting an intensive study of the effect of furnace conditions on the so-called load test for the limit of strength of a refractory. This work, now brought to a close, has yielded fundamental data on the effects of temperature, time of heating, rate of increase of temperature, and other factors affecting the physical condition of the brick. These data have been reduced to simple charts and diagrams, so the furnace operator can easily follow the reactions that may be expected for various conditions of operation, for a large variety of refractory materials.

CALENDAR OF CONVENTIONS

Organization	Date	Place
Am. Assn. Advancement of Science	Dec. 28–Jan. 2	Kansas City, Mo.
AMERICAN CERAMIC SOCIETY		
(Annual Meeting)	Feb. 8–13, 1926	Atlanta, Ga.
(Fall Meeting)	Oct. 1, 1925	New York City
Am. Engineering Council	Jan., 1926	
Am. Foundrymen's Association	Oct. 5–9, 1925	Syracuse, N. Y.
Am. Gas Association	Oct. 12–16, 1925	Atlantic City, N. J.
Am. Soc. of Mechanical Engineers	Nov. 30–Dec. 3, 1925	New York City
Am. Zinc Institute	April 27–28, 1926	St. Louis, Mo.
Coal Mining Institute of America	Dec. 9–11, 1925	Pittsburgh, Pa.
Common Brick Manufacturers Assn.	Feb. 22–26, 1926	New Orleans, La.
Mining and Met. Society of America	Jan. 12, 1926	New York City
Natl. Association of Manufacturers	Oct. 26–28, 1925	St. Louis, Mo.
Natl. Brick Manufacturers Assn.	Nov. 2–7, 1925	St. Louis, Mo.
Natl. Exposition of Power and Mechanical Engineers	Nov. 30–Dec. 5, 1925	New York City
Natl. Exposition of Chem. Industries	Sept. 28–Oct. 3, 1925	New York City

Natl. Paving Brick Mfrs. Assn.	Jan., 1926	
Natl. Safety Council	Sept. 28–Oct. 2, 1925	Cleveland, O.
Optical Society of America	Oct., 1925	Ithaca, N. Y.
Sand-Lime Brick Association	Feb. 9–15, 1926	New Orleans, La.
Natl. Society for Vocational Education	Dec. 3–5, 1925	Cleveland, Ohio
Natl. Exposition of Coal Mining Machinery	Dec. 2–5, 1925	Cincinnati, O.

E. J. BABCOCK

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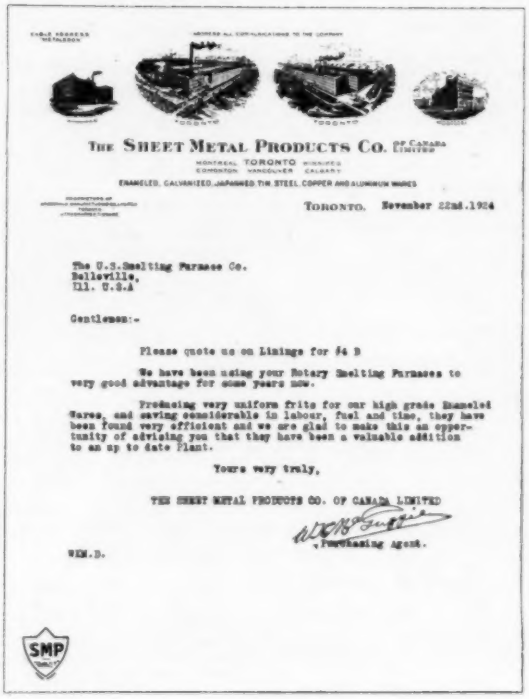

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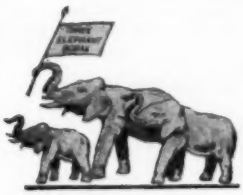

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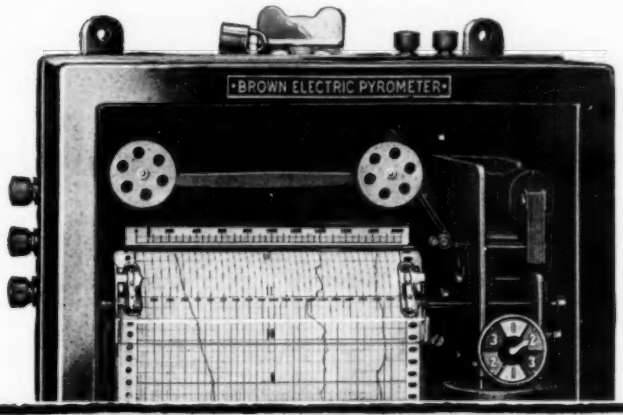

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Use of Sedimentary Kaolins of Georgia in Whitewares.

Kaolin and Refractory Clay Deposits in Wilkinson Co., Ga.

Utilization of Georgia Kaolins in the Manufacture of Face Brick

Distribution of Kaolin and Bauxite of the Coastal Plain of Georgia.

Abundant Raw Material Available

The supply of Kaolin in the Coastal Plain of Georgia along the Central of Georgia Railway is sufficient to meet the needs of the refractory industry for over 600 years. Deposits here cover an area of about 10,000 square miles.

Easy to Mine

Unlike fire clay deposits, Georgia Kaolin is found near the surface where it can be mined at low cost with steam shovels. Deposits run from 10 to 40 feet in thickness with little or moderate overburden. It is estimated that raw material in quantity can be mined at a cost of from 30 to 40 cents a ton as compared to an approximate cost of $1.50 to $2.00 a ton where underground mining is necessary.

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Kaolin refractory brick is made of one clay, thus making it unnecessary to assemble two or more materials from widely separated sources—an economic advantage of great importance when considering the cost of production. Then too, power is reasonable and labor is plentiful.

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The average weight of standard sized kaolin brick is 6½ lbs. as compared to 7 lbs. average weight of standard sized fire-clay brick. This alone means a saving of 500 lbs. per thousand brick—an item which reduces freight costs materially. Then too, freight rates are favorable and finished brick can be shipped either by rail or water to points of consumption. Freight service by rail is maintained to all points in the north and west through the principal gateways. Steamship service from Savannah to all important coast cities and foreign ports.

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The use of Georgia Kaolin for refractory brick is a comparatively new development. There is abundant opportunity to establish a large and prosperous industry here. Many desirable undeveloped properties are available. The Central of Georgia Railway has made a careful survey of deposits in this territory and is in position to furnish valuable suggestions to those interested.

American Ceramic Society Annual Convention, Atlanta, February 8-13, 1926

Central of Georgia Railway

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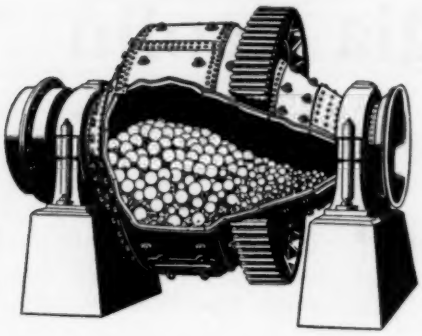

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ALPHABETICAL LIST OF ADVERTISERS

	Page
American Rolling Mill Co.	11
American Trona Corp.	7
Best, W. N. Corp.	26
Brown Instrument Co.	9
Carborundum Co.	32
Caulkins & Co., H. J.	20
Central of Georgia Railway	17
Chambers Brothers Co.	24
Chicago Vitreous Enamel Products Co.	7
Drakenfeld and Co., B. F., Inc.	15
Edgar Plastic Kaolin Co.	25
Engelhard, Charles, Inc.	27
Eureka Flint & Spar Co.	3
Ferro Enamel Supply Co.	25
General Electric Co.	35
Hadfield-Penfield Steel Co.	27
Hardinge Co.	18
Harshaw, Fuller and Goodwin Co.	2
Holcroft & Co.	23
Hy-Grade Manganese Co., Inc.	23
Innis, Speiden & Co., Inc.	26
Journal of the Society of Glass Technology	21
Lancaster Iron Works, Inc.	30
Leeds & Northrup Co.	1
Mansfield Sheet & Tin Plate Co.	30
McDanel Refractory Porcelain Co.	23
Montgomery Porcelain Products Co.	24
Mueller Machine Co., (Inc.)	20
National Silica Co.	31
Newark Wire Cloth Co.	7
Norton Co.	34
Paper Makers Importing Co. (Inc.)	33
Parker-Russell Co.	23
Pennsylvania Pulverizing Co.	26
Philadelphia Drying Machinery Co.	38
Porcelain Enamel & Mfg. Co.	Inside Back Cover
Potters Supply Company	31
Proctor and Schwartz, Inc.	4
Professional Directory	28
Roessler and Hasslacher Chemical Co.	Inside Front Cover
Seaboard Fuel Corporation	22
Surface Combustion Co.	29
Titanium Alloy Mfg. Co.	13
United Alloy Steel Corp.	36
United Clay Mines Corp.	23
U. S. Smelting Furnace Co.	5
Vitro Manufacturing Co.	Outside Back Cover
Watson-Stillman Co.	24

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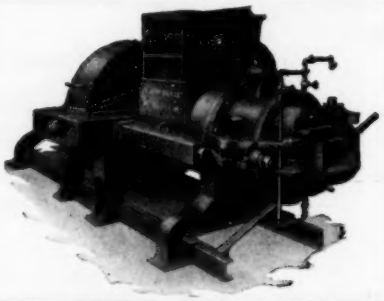

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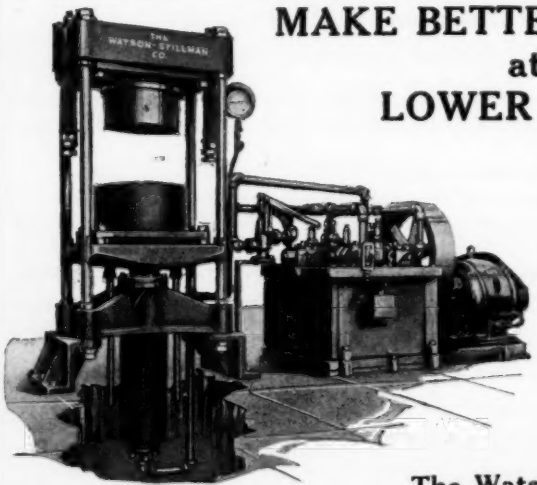

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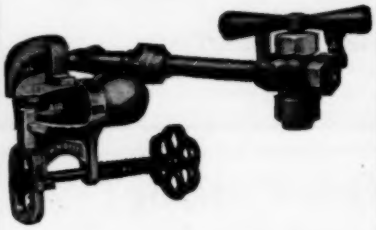

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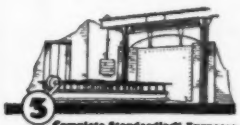

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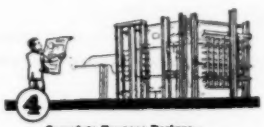

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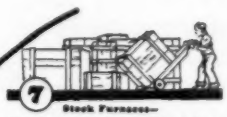

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- AutoClay Cleaner
- Granulators
- Disintegrators
- Crushers
- Steam Pipe Rack Brick Dryers
- Cable Conveyors
- Winding Drums
- Belt Conveyors
- Brick Moulds
- Clay Storage Systems
- Clay Cars
- Kiln Castings
- Tanks and Stacks

Your Clay Working Plant Deserves a Good Pug Mill

Nowhere is good machinery more important than in properly tempering clay.
A Lancaster Pug Mill stands between you and upkeep cost. It stands between you and losses in production by delivering a uniformly mixed clay which makes a better finished clay product. It is tremendously sturdy and strong and specialized to its work in the minutest detail.
Through long years of close contact with brick making processes, Lancaster Engineers are in a position to make valuable suggestions. You may find their advice exceedingly worth-while in your particular needs. Write to them today.

LANCASTER IRON WORKS, Inc.
LANCASTER, PENNSYLVANIA
BRICK MACHINERY DEPARTMENT JAMES P. MARTIN, Manager

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After an exhaustive study of the requirements of the Enameling Industry we are producing:

WABIK METAL SPECIAL VITREOUS ENAMELING SHEETS

Unlike ordinary steel sheets, warping and blistering is reduced to a minimum, thus increasing the Enameler's output and profit.

Many of the leading plants now recognize "WABIK METAL" as the supreme stock for that beautiful permanent lustre which is so essential in Table Tops, Stove Parts, Refrigerator Parts, Signs, etc.

THE MANSFIELD SHEET & TIN PLATE CO.
MANSFIELD, OHIO

SERVICE TO POTTERS

We Manufacture—	*We Sell—*
PINS	BALL CLAY
STILTS	SAGGER CLAY
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TILE for Decorating kilns	IMPORTED PARIS WHITE

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The National Silica Co.

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99.97% Pure Silica *140 Silk Lawn Test*

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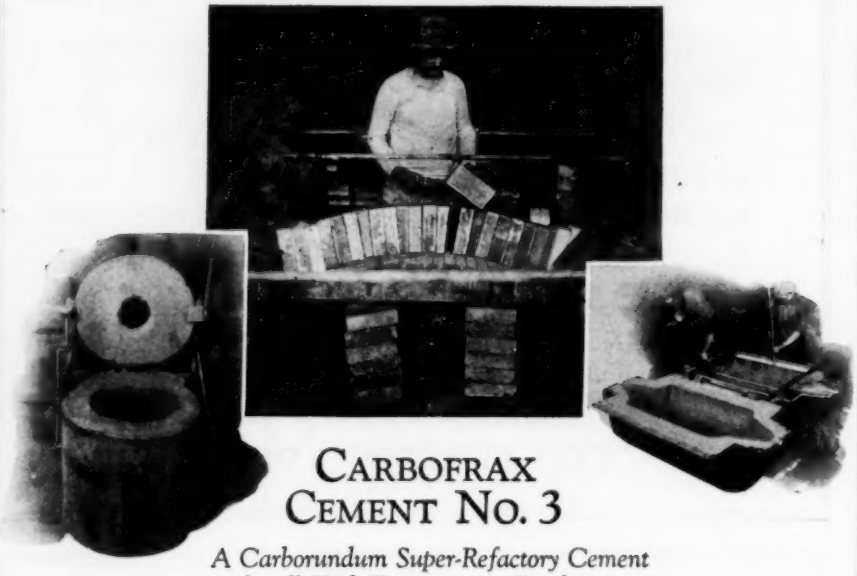

CARBOFRAX CEMENT NO. 3

A Carborundum Super-Refactory Cement for all High Temperature Conditions

CARBOFRAX Cement No. 3 is composed principally of Carborundum, one of the most refractory of all materials, hence its remarkable heat resisting properties. It is a Cement so compounded that it will set hard and durable at room temperature.

It will quickly vitrify when heated and its range of vitrification is so wide that it can be used under varying temperature conditions.

Carbofrax Cement No. 3 can be used for practically all high temperature work—for making rammed in linings—for patching brass melting furnaces—for laying up fire brick and patching boiler furnace linings.

It gives a dense hard lining that will not slag or fuse out.

In laying up fire brick it gives a joint far more refractory than the brick itself—a joint that will not soften, melt or bubble or burn out under the severest flame impingement.

Used as a wash it provides a protective coating that adds months to the life of fire brick.

Carbofrax Cement No. 3 is a super-refractory cement in every sense of the title—shipped dry—just add water and apply.

SAMPLES WILL BE GLADLY SENT UPON REQUEST

CARBORUNDUM REFRACTORIES

Brick and Tile for Boiler and Furnace Settings; Muffles for Enameling Furnaces; Hearths for Heat-Treating Furnaces; Cements for all High Temperature Work

Manufactured by THE CARBORUNDUM COMPANY, PERTH AMBOY, N.J.

Pittsburgh : Chicago : Cleveland

Refractory Products Co., Chicago
Corning-Donahue, Inc., St. Paul, Minn.
Christy Firebrick Co., St. Louis, Mo.
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Resist fusing or softening
Are easily workable
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Resist temperature changes
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The first property is obtained by using as a basis a maximum quantity of a highly refractory material such as crystalline alumina, silicon carbide, or fused magnesia. These substances are very different from fireclay, the basis of many cements.

Workability is obtained by the use of refractory binders which mature under heat. These binders, or bonds are carefully adapted to the three basic refactory materials.

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Twelve standard mixtures are carried in stock, giving a range of application covering all ordinary industrial processes. For several well-known companies we have developed special mixtures to meet unusual requirements.

Write for our cement and refractory catalog.

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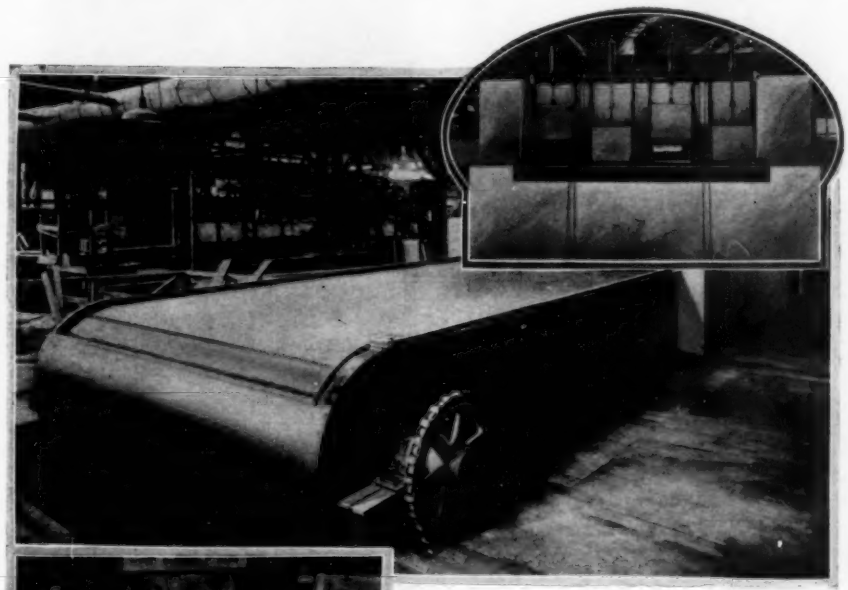

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United Alloy decided that the enameler's requirements were of a special nature—a study in themselves—and set about devising materials and methods to overcome the defects in enameling stock.

The result of this research has been of tremendous help to the enameling industry.

Toncan Enameling Sheets receive special treatment through every step of the manufacturing process to make them the most satisfactory sheets the enameler can obtain.

This skillful, specialized treatment is reflected in the results the enameler gets. If you have never used Toncan, write and let us send you complete information.

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UNITED ALLOY STEEL CORPORATION
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TONCAN ENAMELING SHEETS

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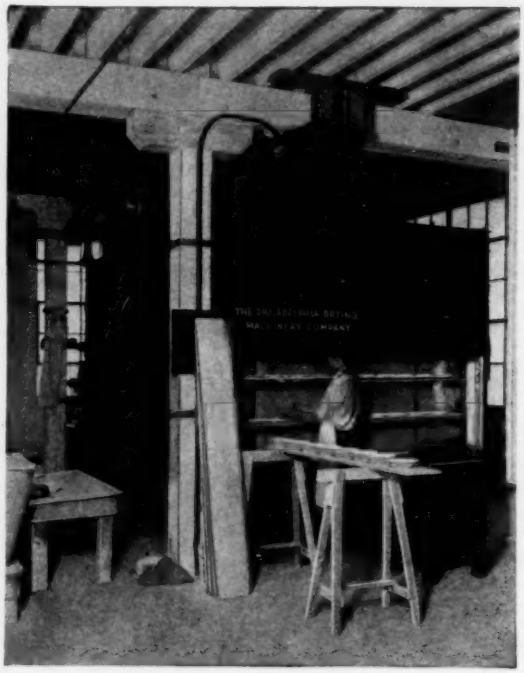

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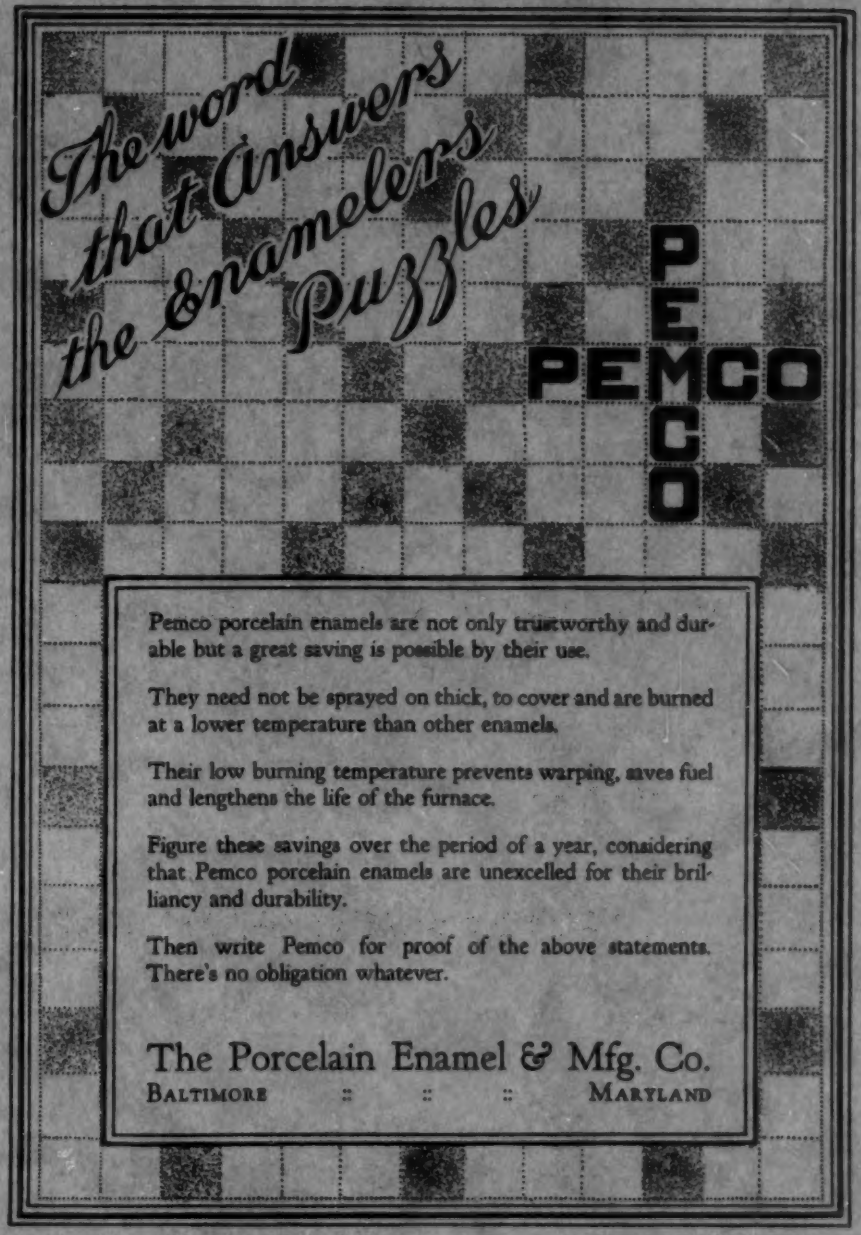

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They need not be sprayed on thick, to cover and are burned at a lower temperature than other enamels.

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Figure these savings over the period of a year, considering that Pemco porcelain enamels are unexcelled for their brilliancy and durability.

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